

Optimizing Investments for a Sustainable and Efficient HIV Response in Senegal



December 2016

Findings from an HIV Allocative Efficiency Study



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OPTIMIZING INVESTMENTS FOR A SUSTAINABLE AND EFFICIENT HIV RESPONSE IN SENEGAL

FINDINGS FROM AN HIV ALLOCATIVE
EFFICIENCY STUDY

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ACRONYMS AND ABBREVIATIONS

AIDS	Acquired immunodeficiency syndrome	NHA	National health accounts
ART	Antiretroviral therapy	NSP	National Strategic Plan
DALY	Disability-adjusted life year	OVC	Orphans and vulnerable children
DSA	Disease specific accounts	PWID	People who inject drugs
FSW	Female sex worker	PWUD	People who use drugs
GARPR	Global AIDS response progress report	PLHIV	People living with HIV
GDP	Gross domestic product	PMTCT	Prevention of mother-to-child transmission
GNI	Gross national income	RBF	Results-based financing
HDI	Human development index	SBCC	Social and behavior change communication
HIV	Human immunodeficiency virus	STI	Sexually transmitted infection
HR	Human resources	UHC	Universal health coverage
HTC	HIV testing and counseling	UNAIDS	Joint United Nations Programme on HIV/AIDS
KP	Key population	UNGASS	United Nations General Assembly Special Session
MCH	Maternal and child health	UNICEF	United Nations Children Fund
MOH	Ministry of Health	UNSW	University of New South Wales
MSM	Men having sex with men	USAID	The United States Agency for International Development
NACC	National AIDS Control Council	WHO	World Health Organization
NASA	National AIDS spending assessment	YLL	Years of life lost
NGO	Non-governmental organization		

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EXECUTIVE SUMMARY

BACKGROUND

This report summarizes the findings of an allocative efficiency analysis to support Senegal's national HIV response. Senegal has recently developed a National HIV Strategic Plan (NSP) (2014–17) and a Global Fund concept note (2015–17). The Government of Senegal would like to mobilize additional domestic and private resources for comprehensive HIV services to respond to the goals of the national HIV Strategic Plan. To assure that the resources that have been, or will be, mobilized are used in the most efficient way, and to determine the allocation of resources that brings the greatest health benefit, the Government requested the World Bank to conduct this allocative efficiency analysis (Section 1), using the Optima mathematical model (Section 4 and Annex).

The HIV epidemic in Senegal is concentrated (Section 3). HIV prevalence among people aged between 15 and 49 years was estimated to be 0.5%, which is among the lowest in West Africa, partially because of Senegal's historically strong program for female sex workers (FSW) that contained the epidemic early on. In contrast, among key populations, such as FSWs, men who have sex with men (MSM), and people who use drugs (PWUD), HIV prevalence is considerably higher (18.5% among FSWs, 17.8% among MSM and 5.2% among PWUD).

Senegal's early and timely response to HIV, as well as universal levels of male circumcision, have played a role in preventing a generalized epidemic that is observed in many African countries (Section 3). Almost immediately after the first cases of HIV were confirmed in 1986, the country set up its National AIDS Control Council (NACC). Free antiretroviral therapy (ART) was introduced in 2003. As of 2015, HIV-positive persons with a CD4 count of 500 cells/mm³ and lower are eligible to initiate ART. For pregnant women, Senegal has implemented Option B+, providing all HIV-infected pregnant and breastfeeding women with life-long ART for prevention of mother-to-child transmission (PMTCT). Other prevention interventions include programs targeted at the general population and key populations, and comprise of social and behavioral change communication (SBCC), distribution of male and female condoms, and voluntary HIV testing and counseling (HTC). ART coverage in Senegal is

Senegal's early and timely response to HIV, as well as universal levels of male circumcision, have played a role in preventing a generalized epidemic that is observed in many African countries.

38%, which is above the West and Central Africa average of 24% but below the global average of 46%.

Senegal's HIV response relies heavily on international funding (Section 3). In 2013, 72% of the total HIV funding came from international donors, with the Global Fund being the largest donor, contributing 42% of the total HIV budget. Public domestic funding covered 20%, and private funding (mainly direct household contributions) 8% of the total funding. Funding from the Global Fund has been decreasing since 2013, leading to a decrease in the total HIV budget envelope, and is secured only until 2017. The major areas of expenditure for the national HIV response in 2013 were management and administration (33%), treatment (31%), and non-ART prevention (25% of the total budget).

In collaboration with stakeholders from Senegal, the following specific questions for an optimization analysis were set:

- How close will we get to National Strategic Plan targets under current funding if allocations are (i) unchanged, or (ii) optimized?
- How much funding is required to achieve Senegal's National Strategic Plan Impact targets?
- What is the expected future impact of different policy or program implementation scenarios, including the future trajectory of Senegal's HIV epidemic if: (i) non-ART HIV prevention programs for key populations are defunded; (ii) the PMTCT program is scaled up to cover 90% of all pregnant and breastfeeding women (from 51%); (iii) the UNAIDS' 90/90/90 goals¹ are reached; (iv) a 'test-and-treat' strategy² is implemented? For each, what is the expected impact on the HIV epidemic and on long-term HIV-related costs?

METHODS

The analysis was conducted using Optima, which is an epidemiological and economic model of HIV transmission with a resource optimization feature (Section 4 and Annex). For the analysis, the inputs into the Optima model were gathered through a comprehensive literature review and key parameters were defined using a participatory consultation of key stakeholders. Local demographic, epidemiological and programmatic data were used to populate the model. Population data for key populations (FSW, MSM, PWUD) were extrapolated to the national level using data from Dakar. Cost and expenditure estimates were derived from the National AIDS Spending Assessment (NASA).

¹ By 2020, 90% of all people living with HIV know their HIV status, 90% of all people with diagnosed HIV infection receive sustained antiretroviral therapy and 90% of all people receiving antiretroviral therapy have viral suppression.

² A test-and-treat strategy involves the initiation of ART to all people testing HIV positive, regardless of baseline CD4 count.

KEY FINDINGS

1 HIV epidemic is of moderate size but in decline: The Optima model estimated a total of 2,500 new infections and 2,200 HIV-related deaths to have occurred in 2014. While the majority of new infections were acquired by children and women aged between 25 and 49 years (due to the relatively larger population sizes), the majority of new HIV infections (just over 50%) estimated to be transmitted as a result of sex work (from sex workers and their clients to the low-risk female population). HIV incidence in 2014 was clearly higher among the key populations (1.54, 1.35 and 0.55 per 100 person years for FSW, MSM and PWUD respectively) than among the overall population (0.03 per 100 person years). Overall, the disease burden is moderately high but has been in decline since the mid 2000s.

HIV incidence in 2014 was clearly higher among the key populations (1.54, 1.35 and 0.55 per 100 person years for FSW, MSM and PWUD respectively) than among the overall population (0.03 per 100 person years).

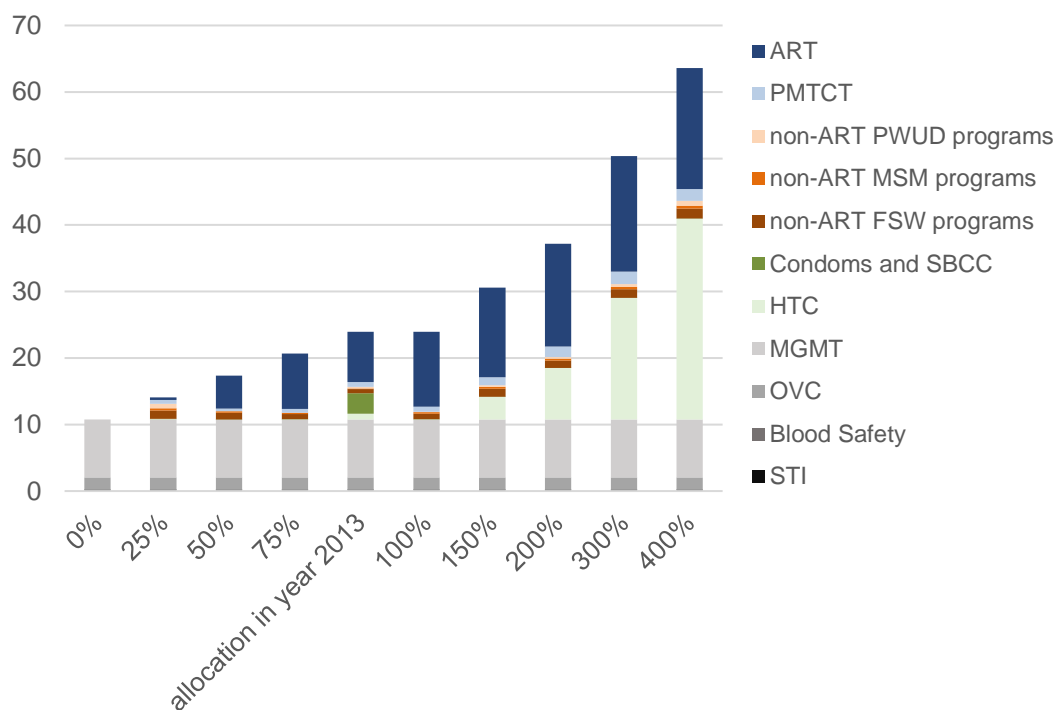
2 Substantial epidemiological improvements are possible through improving the allocative efficiency of the HIV response during the National Strategic Plan period (2014–17) without increasing the overall budget of US\$ 24 million per year: The investments (and allocations across programs) made by the country over its current National Strategic Plan (NSP) period are estimated to reduce the number of new HIV infections by 400 (14.8%) and reduce the number of HIV-related deaths by 100 (4.3%) by 2017 compared to the 2013 baseline. If this current budget was allocated optimally, the number of new infections would be reduced by 900 (49.3%) and the number of HIV-related deaths would be reduced by 550 (31%) by 2017 compared with 2013. This means that with the same budget but allocated optimally, Senegal could almost reach its NSP impact target of reducing new HIV infections by 50% and make a significant step towards reaching its second impact target of reducing HIV-related deaths by 50%. The optimal allocation of resources would prioritize ART (for all) and non-ART prevention programs for FSW and MSM.

3 Further improvements are possible with more efficient management and funding some programs from other sources: Currently, 33% of HIV resources are spent on management and administration. In addition, there are programs with benefits beyond HIV/AIDS such as blood safety and programs for orphans and vulnerable children (OVC) including social protection support, that are funded from the HIV budget. If the management of the HIV program could be made more efficient, and OVC programs (including social protection) and blood safety are funded from other non-HIV sources, the budget available for direct HIV programs would increase by over USD 3.5 million each year. These additional resources, optimally allocated, would result in the reduction in the number of new

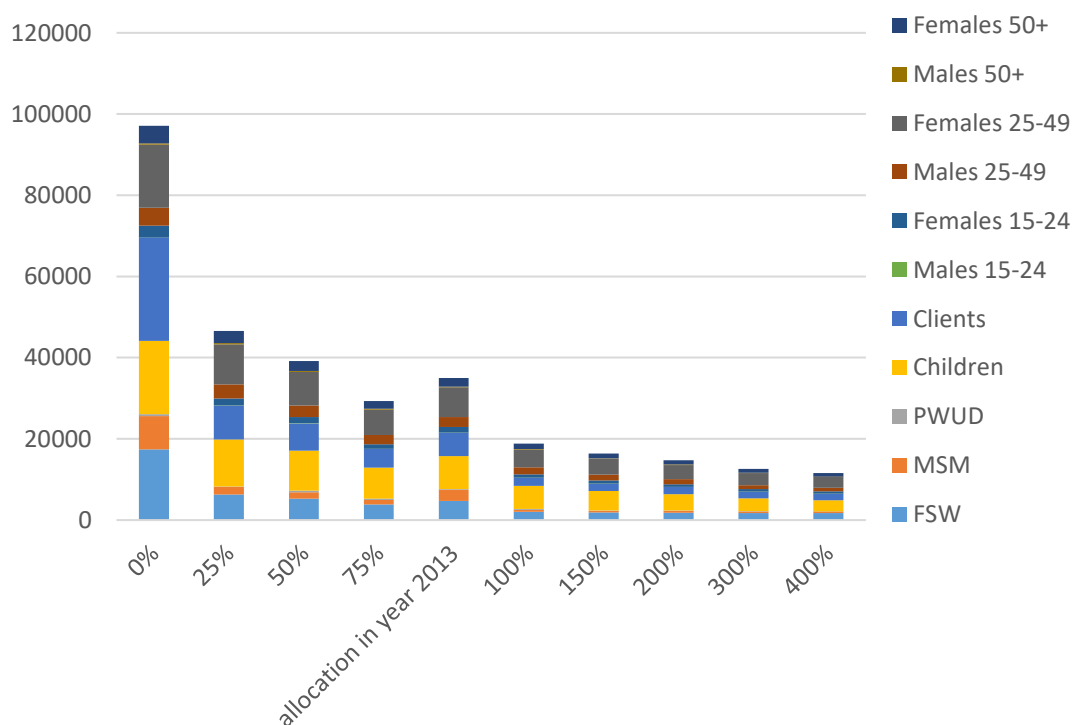
HIV infections by 980 (52%) and the number of HIV-related deaths by 620 (34%) by 2017 compared with 2013.

- 4 In order to reach the NSP targets of reducing both new HIV infections and HIV-related deaths by 50%, it would be necessary to invest an additional USD 22 million per year;** that is, approximately double the current annual HIV expenditure. With the current budget, reaching both targets will not be possible.
- 5 For maximum long-term impact (2015–30), achieved through an optimal allocation³ of the current budget of US\$24 million per year, HIV financial resources should be shifted to the scale-up of HIV treatment (for the general and key populations) and prevention programs targeting the key epidemic drivers (FSW and MSM),** as shown in Figure ES2. Such a shift in allocation would avert an estimated 16,100 additional HIV infections and 10,200 additional deaths during the period 2014–30 compared with the current unoptimized allocation. If the management of the HIV program could be made more efficient and OVC (including social protection) and blood safety funded from other sources, the budget available for direct HIV prevention and treatment programs would increase by over USD 3.5 million each year. These extra resources for direct HIV programs could avert 17,500 new infections (1,400 additional compared to the optimal allocation without decreasing the budget for management and OVC and blood safety) and 12,300 (2,100 additional compared to the optimal allocation without decreasing the budget for management and OVC and blood safety) HIV-related deaths by 2030.
- 6 If HIV funds are either very limited or more abundant, allocations can be guided by an investment staircase that helps prioritize expenditures by HIV impact:** If the total HIV budget decreases (below what has actually been acquired for the NSP period), ART for the general and key populations should be given first priority, followed by spending on non-ART prevention programs targeting FSW and MSM. With the decreased budget, easily preventable HIV infections and deaths will occur. With a 25% budget decrease in the budget available for optimization (total budget decreases from USD 24 million to USD circa 21 million per year), for example, Optima results suggest that HIV incidence would increase by 55% and HIV deaths would increase by 33% compared with the optimal allocation of the current available resources. If the Senegalese government is successful in mobilizing additional resources, then the investment staircase also suggests how such larger resource envelopes should be allocated. With a 150% of the budget available for optimization (circa a total budget of USD 31 million per year), for example, Optima results suggest that HIV incidence would decrease by 13% and HIV deaths would decrease by 16% compared with the optimal allocation of the current resources. The investment staircase shows these scenarios (Figures ES 1–3 below).

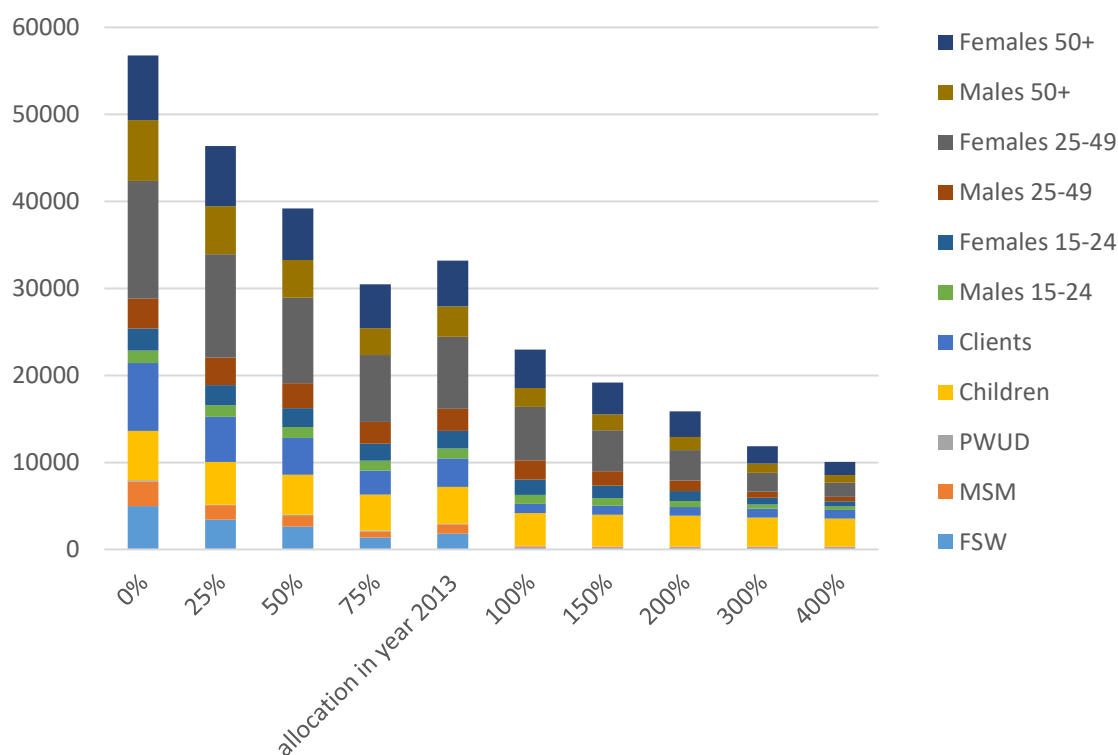
³ Calculated as the best combination of programs to reduce HIV incidence and mortality as much as possible.

Figure ES 1 Investment staircase for HIV investment

Source: Authors

Figure ES 2 Total number of new infections that would result from different spending scenarios between 2014 and 2030

Source: Authors

Figure ES 3 Total number of hiv related deaths that would result from different spending scenarios between 2014 and 2030

Source: Authors

The Optima model was also used to analyze the influence of different scenarios on the projected future trajectory of the country's HIV epidemic. The following key results were obtained:

- **Defunding HIV prevention programs targeting key populations** would have a significant negative impact on the HIV epidemic as well as on long-term HIV-related costs. It is estimated that defunding HIV prevention programs for key populations would result in 22,700 more new infections (10,600 in key populations and 11,100 in the general population) and 4,000 more HIV-related deaths (1,400 in key populations and 2,600 in the general population) by 2030. Cumulative HIV-related costs between 2014 and 2030 would also increase by 17.9 million USD.
- **Scaling up the PMTCT program to cover 90%** (from 51%) of all pregnant and breastfeeding women would prevent 800 mother-to-child transmissions of HIV between 2014 and 2017, and 2,600 mother-to-child-transmissions between 2014 and 2030.
- **If Senegal attained the global 90/90/90 targets by 2020**, 17,300 additional new infections and 12,600 HIV-related deaths would be averted by 2030. Reaching 90/90/90 would however be expensive—the cumulative HIV-related costs would increase by USD 156 million by 2030.

- **A ‘test and treat’ strategy would have a significant positive impact on the HIV epidemic** averting 22,800 new infections and 25,000 HIV-related deaths by 2030. The cumulative costs related to HIV between 2014 and 2030 would, however, increase by 60%, from 615 million with current conditions to around 985 million US dollars.

CONCLUSION

Our analysis has shown that Senegal’s concentrated HIV epidemic is on the decline, and will continue to decrease somewhat (if current levels of funding can be maintained), but not to the levels desired in National HIV strategy goals (as articulated in the 2014–17 National Strategic Plan (NSP)). With the current allocation of the resources across programs and populations, the country will not be able to achieve its NSP targets of reducing new HIV infections and HIV-related deaths by 50% by 2017. With an optimal allocation of financial resources, however, Senegal could almost reach its target of reducing new HIV infections and HIV-related deaths by 50%. This would favor a shift from prevention programs targeting the low-risk general population towards treatment for everyone and non-ART prevention programs targeting key and vulnerable populations (FSW and MSM). These shifts in allocation emphasize the relatively high effectiveness of ART in population-level reductions in transmission and for individual clinical benefit. They also highlight the concentrated nature of Senegal’s HIV epidemic and therefore recommend a shift away from non-ART prevention programs targeting the low-risk general population.

With an optimal allocation of financial resources, Senegal could almost reach its target of reducing new HIV infections and HIV-related deaths by 50%.

The opportunity cost of not maintaining what has historically been a very successful program will be negative for the country and the region.

There is a real opportunity to engage with the private sector to increase domestic financing particularly for high-impact interventions needing scale-up, such as ART programs for FSW. In addition, Senegal is in an ideal position to integrate HIV within its universal health coverage (UHC) program.

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Section 1

INTRODUCTION

In an increasingly resource-constrained environment, today's HIV responses are faced with the double challenge of scaling-up targeted but comprehensive HIV services that reduce the transmission of HIV and treating a larger number of people living with HIV than ever before, as well as doing more with available resources.

In the past, HIV responses in many countries around the world attempted to provide a wide range of services using multiple approaches. At a time of increasing resource envelopes, this was useful in testing and learning from different interventions and service delivery modalities. However, it also led to fragmentation of responses and thereby limited focus on scaling up the highest-impact programs. Today, in an environment of limited resources, focused and efficient HIV program design and delivery is essential to ensure that programs can do more with the available resources.

1.1 ALLOCATIVE EFFICIENCY IN HIV AND HEALTH

The concept of allocative efficiency takes health interventions (including services, drugs, and other activities, the primary intention of which is to improve health) as inputs and the health of the population as an output⁴. The term allocative efficiency refers to the maximization of health outcomes with the least costly mix of health interventions. Practically, allocative efficiency of health interventions is about the right interventions being provided to the right people at the right place in such a way that health outcomes are maximized.

HIV allocative efficiency studies are generally trying to answer the question "How can HIV funding be optimally allocated to the combination of HIV response interventions that will yield the highest impact (achieve HIV response goals in the areas of HIV prevention, treatment, care and support) in the shortest period of time?"

The term allocative efficiency refers to the maximization of health outcomes with the least costly mix of health interventions.

The dialogue around HIV financing has been changing in recent years, from a focus on universal access and estimation of the total resource needs to comprehensively finance

⁴ WHO (2003). Policy tools for allocative efficiency of health services. Xingzhu Liu.

universal access, to prioritized high-impact HIV response scenarios within the realistic constraints of an amount of funding a country is likely to raise. In connection with this, the following developments can also be highlighted:

- The shared interest to move towards more predictable levels of HIV funding support for countries
- The promotion of better alignment between HIV investment decisions and “need”, informed by disease burden and ability to pay
- The concept of shared responsibility or “fair share” promoted by UNAIDS, calling on governments to contribute public sector funds to the HIV response
- The stabilization of most HIV epidemics globally, resulting in a change from HIV’s special disease status to a chronic condition with long-term treatment needs similar to some non-communicable diseases in many settings
- The move from vertical HIV interventions to more integrated HIV and health service provision with strong linkages to TB and Sexual and Reproductive Health (SRH) services and the management of chronic conditions
- The change from an HIV/AIDS spending approach towards an investment approach, using longer time horizons, and analytical approaches to determine where investments should be made

There is wide consensus that **better outcomes could be achieved in many settings with a given amount of HIV funding, or given outcomes could be achieved with less HIV funding, if the resources were distributed optimally, or if resources were technically used in the most efficient ways.** Mathematical modeling can be used to determine the optimal HIV resource allocation. As an HIV allocative efficiency model, Optima is designed to provide investment guidance on allocatively efficient HIV responses. The optimal allocation of resources predicted by the model differs depending on the policy objective(s), and the optimal distribution of resources across programs changes substantially based on the amount of funding available to be allocated.

The Optima model:

- is a mathematical model of HIV transmission and disease progression that is population-based and flexible
- provides a formal method of optimization that quantitatively and objectively determines optimal allocations of HIV resources across numerous prevention and treatment programs to address multiple policy objectives
- estimates intervention impact, cost-effectiveness and return-on-investment
- provides analysis on the longer-term financial consequences of HIV infections and HIV investments

1.2 RATIONALE FOR AN HIV ALLOCATIVE EFFICIENCY ANALYSIS IN SENEGAL

Senegal has recently developed a new HIV National Strategic Plan (NSP; 2014–17) and a Global Fund concept note (2015–17). Given the country's heavy reliance on international financing for the national HIV response, with over 70% of the response internationally financed, the Government would like to increase domestic financing, particularly through resource mobilization from the private sector and through innovative financing mechanisms.

The Government would also like to ensure that all the funding that it has already mobilized, or will mobilize in the future, has and will be allocated in an optimal way to maximize health and HIV outcomes – thus maximizing the effectiveness of the existing and any new resources that are mobilized. In this regard, the Government requested technical support from the World Bank to undertake an allocative efficiency analysis using the Optima model, the key results of which are presented in this report. The recommendations from this study will help provide answers to these questions:

- a. How the existing funding could be allocated more efficiently
- b. How the additional funding needed to achieve the HIV program goals should be allocated

Answers to these questions will help to influence program resource allocation to more efficient program spending, and inform the development of the country's HIV resource mobilization strategy.

1.3 OBJECTIVES OF THE ANALYSIS

Senegal has set the priorities for its HIV response in the National Strategic Plan (NSP) (2014–17) including the following key impact targets:

- Reduce the annual number of new HIV infections by 50% compared to the 2013 baseline
- Reduce the annual number of AIDS-related deaths by 50% compared to the 2013 baseline

In collaboration with stakeholders in Senegal, the following questions for an optimization analysis were set:

- How close are we to National Strategic Plan targets under current funding?

Over the NSP period, how close will Senegal get to their NSP's disease-related targets:

- With the current volume of funding, allocated according to current expenditure?

- With the current volume of funding, allocated optimally?

■ How much funding is required to achieve Senegal's National Strategic Plan IMPACT targets?

Over the National Strategic Plan period, according to current program implementation practices and costs:

- How much total funding is required to meet the National Strategic Plan targets?
- How is this funding optimally allocated between programs?

■ What is the expected future impact of various policy or program implementation scenarios?

For this question, the analysis investigated a number of scenarios to assess the projected future trajectory of the country's HIV epidemic. Scenarios assessing investments in specific programs, attaining program-specific or international targets as well as different treatment eligibility policies were assessed. These are described in detail in Section 4.4.

Section 2

SENEGAL'S HUMAN DEVELOPMENT, HEALTH AND HEALTH FINANCING CONTEXT

2.1 HUMAN DEVELOPMENT

Senegal is located in West Africa, with an area of 197,000 km², and is sub-divided into 14 administrative regions (Figure 2.1). The country is categorized as a lower middle-income country and has a population of 14.7 million people (2014). About half of the population lives in urban areas. The main economic sectors of Senegal include fishing, agricultural production, natural resources, and tourism. The economy is dominated by the agricultural sector with three quarters of the workforce engaged in agriculture, the majority in subsistence farming.

Figure 2.1 Map of Senegal and its administrative regions



Source: World Bank

Human development is usually measured by the human development index (HDI), which depends on three basic dimensions of human development: 1) A long and healthy life; 2) Access to knowledge and 3) Standard of living. In 2014, Senegal had a HDI of 0.466, ranking it 170th out of 188 countries in the world⁵. Though this figure represents one of the lowest HDI in the world (being also below the sub-Saharan Africa average of 0.502), Senegal's HDI has increased by 43.4% since 1980 (1.06% average annual increase)⁵.

This increase in HDI between 1980 and 2014 is a result of an increase in life expectancy (by 17.6 years), mean years of schooling (by 0.3 years), expected years of schooling (by 4.3 years) and the gross national income (GNI) per capita (by 15%)—the most commonly used indicator for standard of living—over the same period⁵.

2.2 BURDEN OF DISEASE

According to the Global Burden of Disease study⁶, the total number of disability-adjusted life years (DALY) in Senegal in 2012 was 6.85 million (49,900 DALYs per 100,000 person-years). A DALY is a measure that takes into account the life-years lost, as well as the life-years lived with disability. The proportions of DALYs in Senegal caused by different conditions are as follows: Non-communicable diseases (32%); Infectious and parasitic diseases (excluding HIV) (26%); HIV (2%); Maternal and perinatal conditions (17%); Respiratory infections (11%); Injuries (8%); and Nutritional deficiencies (4%).

The infectious diseases with the highest burden were malaria (629,700 DALYs, or 32% of DALYs due to infectious diseases), diarrheal diseases (392,000 DALYs, or 17% of DALYs due to infectious diseases), meningitis (181,500 DALYs, or 9% of DALYs due to infectious diseases), and tuberculosis (163,800 DALYs, or 8% of DALYs due to infectious diseases). HIV infection represents a small proportion of the total burden of disease: 2% of all DALYs, or 6% of DALYs due to infectious diseases. However, HIV/AIDS has been one the leading cause of emerging disease burden, being the only infectious disease whose burden has increased over the last 20 years (by 620% since 1990)⁷. In addition, several top causes of local disease burden—such as iron deficiency anemia, malnutrition, TB and diarrhea—interact with the immunocompromised

HIV/AIDS has been one the leading cause of emerging disease burden, being the only infectious disease whose burden has increased over the last 20 years (by 620% since 1990).

⁵ United Nations Development Programme. Human Development Data, 1980–2015. <http://hdr.undp.org/en/data>

⁶ World Health Organization. Global Burden of Disease Estimates. www.who.int/healthinfo/global_burden_disease/estimates/en/index2.html, 2015.

⁷ Institute for Health Metrics and Evaluation. Senegal data. <http://www.healthdata.org/senegal>.

status of HIV-positive individuals and are likely to accelerate disease progression and morbidity. The relatively small burden of HIV in Senegal also suggests that it may be a manageable public health issue.

2.3 HEALTH SYSTEM AND HEALTH FINANCING

Senegal's healthcare system is managed by the Ministry of Health (MOH), private companies and the armed forces⁸. The MOH is the largest health care provider, managing about 1,200 hospitals and clinics. These include 9 national hospitals located in the capital Dakar, 13 regional hospitals (one located in each regional capital), about 70 district health centers and more than 1,100 health and/or maternity posts, which are run by a nurse or a midwife. There are about 440 privately operated clinics. The armed forces manage 44 health care facilities, which are open for both military personnel and the local civilian population.

Health spending in Senegal has increased over the last decade, with per capita health expenditure increasing two-fold from USD 22 in 2000 to USD 44 in 2013⁹. However, this is still less than half of the African regional average of USD 105. According to the World Health Organization (WHO), spending of at least USD 44 per capita is needed from the government as a minimum per year in order to provide basic, life-saving services¹⁰. While overall spending (and Government spending) on health per capita has increased, the proportion of the gross domestic product (GDP) that was spent on health was only 4.3% in 2012, which is lower than what it was in 2000 (4.6%) and also lower than the African regional average (5.6%). It is also below the benchmark of 5–6% of GDP, which has been set by WHO to reduce the number of households whose health expenditure increases to catastrophic levels¹¹. Government spending on health in terms of total health expenditure was 50.6% in 2012. Government spending on health as a percentage of the government's total spending is 7.5% in Senegal, which is below the Abuja Declaration target of 15%. While private expenditure has reduced, it still represents almost half (49.4%) of all domestic spending on health, and more than three-quarters of this (77.4%) are out-of-pocket payments.

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⁸ Tine, Justin, Sophie Faye, Sharon Nakhimovsky, and Laurel Hatt. April 2014. Universal Health Coverage Measurement in a Lower-Middle-Income Context: A Senegalese Case Study. Bethesda, MD: Health Finance & Governance Project, Abt Associates Inc.

⁹ World Health Organization. World Health Statistics Report, 2015.

¹⁰ World Health Organization. Spending on health: A global overview. 2012. <http://www.who.int/mediacentre/factsheets/fs319/en/>

¹¹ World Health Organization. World Health Report 2010. Health systems financing, the path to universal coverage

Almost half of out-of-pocket spending is spent on purchasing drugs¹². In 2012, the country's president, Macky Sall, made a pledge to launch a Universal Health Coverage (UHC) program to ensure that all citizens of Senegal have access to the services they need and are able to use these services without risk of financial impoverishment¹³. To help achieve this, the country has three types of risk pooling schemes: mandatory employer-based insurance, voluntary community-based health insurance, and public subsidies for specific services and population groups, including pregnant women, the elderly and children under the age of five years. Private insurance companies provide some additional voluntary coverage, but this market is currently very small. Also in 2012, the country's Ministry of Health and Social Affairs piloted a Results-Based Financing (RBF) program in two regions (Kaffrine and Kolda). This was later expanded to four additional regions with the view of later rolling out the scheme nationally. The objective of the scheme is to reward well-performing health posts and centres based on the attainment of quantitative targets for certain priority programs that are adjusted (with the exception of hospitals) according to a quality rating¹⁴. With support from the World Bank and USAID, the Government has expanded the RBF scheme to six regions through the Health and Nutrition Financing Project for Senegal (2013–18)¹⁵.

¹² Tine, Justin, Sophie Faye, Sharon Nakhimovsky, and Laurel Hatt. April 2014. Universal Health Coverage Measurement in a Lower-Middle-Income Context: A Senegalese Case Study. Bethesda, MD: Health Finance & Governance Project, Abt Associates Inc.

¹³ Abt Associates. 2013. Feature stories. President of Senegal launches Universal Health Coverage Programme. <http://abtassociates.com/Noteworthy/2013/President-of-Senegal-Launches-Universal-Health-Cov.aspx>

¹⁴ KIT Health. 2015. News. Action research on health financing in Senegal. <https://www.kit.nl/health/kit-news/action-research-on-health-financing-in-senegal/>

¹⁵ World Bank. Senegal Health & Nutrition Financing Project. <http://www.worldbank.org/projects/P129472?lang=en>

Section 3

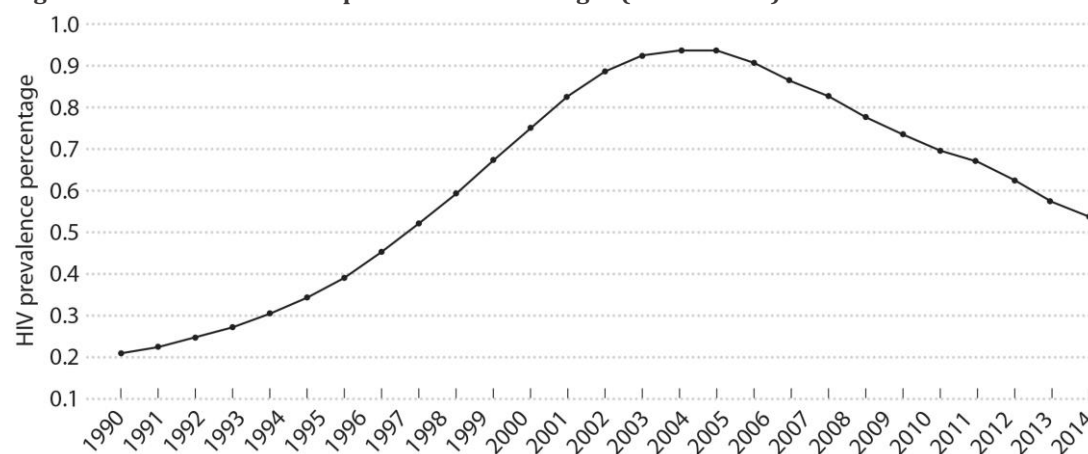
HIV IN SENEGAL

3.1 HIV EPIDEMIC IN SENEGAL

Senegal's epidemic is stable and characterized by feminization and geographical heterogeneity.

It is estimated that 0.5% of the Senegalese population aged between 15 and 49 years are HIV-positive (2014)¹⁶. UNAIDS estimates that 44,000 people were living with HIV in 2014 (i.e., 0.3% of the total population of 14.7 million)¹⁶. HIV prevalence among the adult population increased steadily from 0.2% in 1990 until it reached its peak value of 0.9% in 2004. Since then, the prevalence has been continuously decreasing due, in part, to the early and concerted investments in the HIV response¹⁷⁻²¹ (Figure 3.1).

Figure 3.1 Estimated HIV prevalence in Senegal (1990–2014)



Source: <http://aidsinfoonline.org/devinfo/libraries.aspx/dataview.aspx>

¹⁶ UNAIDS HIV AIDS estimates (2014).

<http://www.unaids.org/en/regionscountries/countries/senegal>

¹⁷ Meda et al. Low and stable HIV infection rates in Senegal: natural course of the epidemic or evidence for success of prevention? *AIDS*. 1999 Jul 30;13(11):1397-405.

¹⁸ UNAIDS (2012). Senegal: a success story of AIDS investments and impact.

<http://www.unaids.org/en/resources/presscentre/featurestories/2012/october/20121011senegal>

¹⁹ Mamadou Mika Lom. Senegal's recipe for success. Early mobilization and political commitment keep HIV infections low. *Africa Recovery*. 2001.

<http://www.un.org/en/africarenewal/vol15no1/15no1pdf/151aid11.pdf>

²⁰ Open Society Institute. HIV/AIDS Policy in Senegal: A Civil Society perspective. 2007.

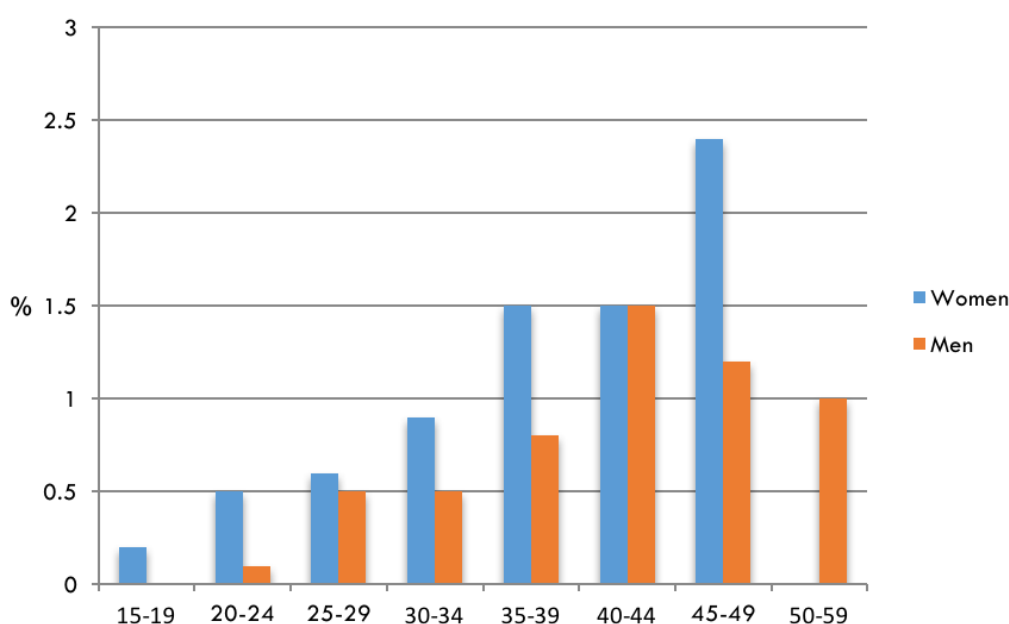
https://www.opensocietyfoundations.org/sites/default/files/senegal_20071015.pdf

²¹ Erin Ballou. Beloit College. HIV in Senegal: Historical, Political, and Cultural Dynamics. 2010.

<http://www.anselm.edu/Documents/NHIOP/Global%20Topics/2010/Balloupaper.pdf>

Like other countries in the region, women are at higher risk of acquiring HIV than men: about 63% of all people living with HIV (PLHIV) in Senegal are women and the prevalence among women is about 0.8%, almost twice as high as in men (0.5%). Gender-specific barriers to access of HIV prevention and care further increase women's vulnerability to HIV. These barriers include: low HIV screening coverage among women in partnerships; limited uptake of family planning; fear of disclosure of HIV status; and giving birth outside health facilities. Other contextual barriers, such as low levels of education and restricted possibilities for decision-making and negotiation, also affect a woman's risk of acquiring HIV. HIV prevalence among women and men increases with age, and is highest among women aged between 45 and 49 years and among men aged between 40 and 44 years (Figure 3.2).

Figure 3.2 HIV prevalence among adult women and men according to age



Source: DHS 2010–11

There are also geographic heterogeneities in HIV burden across Senegal. Overall, HIV prevalence is highest in the Kolda (2.4%) (landlocked, southern part of the country and bordering Guinea-Bissau), Kedougo (1.7%) (landlocked, south-east part of the country and bordering Guinea and Mali) and Tambacoundo regions (1.4%) (landlocked, south-east part of the country and bordering Guinea). The prevalence of HIV in Senegal's neighboring countries (Gambia, Guinea, Guinea-Bissau, Mali, Mauritania) is on average notably higher than in Senegal. Despite these geographic heterogeneities, HIV prevalence overall is the same in urban and rural areas (0.7%). However, HIV prevalence among women is higher in urban areas (0.9%) compared to rural areas (0.7%), whereas among men the opposite is true: HIV prevalence is twice as high in rural areas (0.6%) compared to urban areas (0.3%).

Although HIV/AIDS represents a small part of the national disease burden, the burden amongst certain high-risk and vulnerable populations is much higher.

Female sex workers

In 2010, HIV prevalence among female sex workers (FSW) was estimated to be 18.5%,²² which has changed little compared to 2006, when it was estimated to be 19.8%²³. Sex work is legal in Senegal for women aged 21 years and older, and sex workers are required to register and undergo regular medical examinations²⁴.

There are no national-level studies estimating the size of the FSW population that have been carried out in Senegal. FSW size estimation studies have only been carried out in Dakar, estimating that there were 4,200 FSW (aged 18 years and older) working in Dakar, with more than half of these (57%) being non-registered FSW²⁵. The primary reasons that women do not register as official sex workers include the fear of stigma (reported by 70% of FSW) and being unaware that sex workers need to register (reported by 31% of FSW).

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Men who have sex with men

HIV prevalence among men who have sex with men (MSM) is estimated to be 17.8% and does not vary considerably with age²⁶. There were an estimated 1840 MSM living in Dakar in 2012 (no national-level data are available)²⁷. In Senegal, men who have sex with men are at high risk of transmitting the virus in part because they frequently engage in unsafe sex and risky behavior²⁴. They have a high prevalence of untreated anal sexually transmitted infections (STIs) and rarely use condoms and lubricants²⁴. Stigma, marginalization and self-exclusion are barriers to accessing prevention and care services, and social marginalization and related poverty may drive them to prostitution. Further details on MSM services can be found in Section 3.2.

²² NACC. Enquête nationale de surveillance combinée des IST et du VIH/SIDA (ENSC), 2010

²³ NACC. Enquête nationale de surveillance combinée des IST et du VIH/SIDA (ENSC), 2006

²⁴ National AIDS Control Council. SEN narrative report, 2015

²⁵ Ministère de la Santé et de la Prévention, Division de lutte contre le SIDA et les IST (DLSI), en partenariat avec FHI360. 2012. Etude pour l'estimation du nombre de PS et HSH dans la région de Dakar. Rapport Final

²⁶ ANRS. Évaluer les interventions de prévention des IST et du VIH auprès des homosexuels masculins au Sénégal (ELIHOS), 2013

²⁷ Ministère de la Santé et de la Prévention, Division de lutte contre le SIDA et les IST (DLSI), en partenariat avec FHI360. 2012. Etude pour l'estimation du nombre de PS et HSH dans la région de Dakar. Rapport Final

People who use drugs (injecting and non-injecting)

A recent (2011) survey conducted in Senegal estimated that 1,324 (95% CI 1,281–1,367) people who use drugs (PWUD) are living in the Dakar area²⁸. This survey defined PWUD as people who had either taken drugs intravenously (regardless of the substance) or used heroin or cocaine/crack (regardless of mode of consumption) during the last 3 months. The number of people in Dakar using drugs intravenously was estimated to be 183. HIV prevalence among PWUD overall was 5.2%. HIV prevalence was higher among PWUD who had used drugs intravenously at least once (9.2%). Only 9.1% of PWUD who had used drugs intravenously had been tested for HIV. PWUDs are also sexually active and often do not use condoms. Overall, 80.4% of PWUDs reported they had had sex within the last 12 months: 45.7% had multiple sexual partners, and 53.5% failed to use a condom at least once with a casual partner. The rate of condom use was particularly low among PWUDs who inject drugs (38.5%). Similar national-level data are not available. Details on HIV services for drug users can be found in Section 3.2.

Other vulnerable populations

Other vulnerable populations include mobile populations, prisoners and the armed and security forces.

The mobile population includes both local and migrant populations, such as truckers, vendors, and seasonal workforce. HIV prevalence among truckers was estimated to be 0.6% in 2010²⁹, which is slightly higher than the male average of 0.5%³⁰. For fishermen and gold miners, HIV prevalence was even higher, at 0.8% and 1.3%, respectively²⁹. Mobile populations are at high risk of HIV because of factors linked to their mobility itself (such as moving between regions or countries with higher HIV prevalence levels) and other socio-cultural factors (such as marital status and education). Mobility also often correlates with incidents of paying for sex. HIV prevalence among prisoners was 1.5% overall though considerably higher among female prisoners (4.5%)²⁹. On the other hand, HIV prevalence among the armed and security forces was lower than the national male average, at 0.2%²⁹.

Mobile populations are at high risk of HIV because of factors linked to their mobility itself (such as moving between regions or countries with higher HIV prevalence levels) and other socio-cultural factors (such as marital status and education).

²⁸ ANRS. Rapport de l'enquête auprès des usagers de drogue au Sénégal (UDSEN), 2011

²⁹ NACC. Enquête nationale de surveillance combinée des IST et du VIH/SIDA (ENSC), 2010

³⁰ ANSD. Demographic Health Survey (DHS), 2010–11

3.2 THE NATIONAL HIV RESPONSE

The first cases of HIV were confirmed in Senegal in 1986 and the country has been recognized internationally for its timely and successful response to the epidemic and its continued efforts and commitment.

Almost immediately after the first cases of HIV were confirmed in 1986, the country set up its National AIDS Control Council (NACC), introducing the systematic screening of all blood for HIV as well as sentinel surveillance of HIV in Senegal's major urban areas focusing on pregnant women, female sex workers and symptomatic men attending STI centers. Education on sex and HIV prevention was integrated into the school curriculum for all children aged 12 years and older in 1992. HIV prevention services for sex workers, including HIV education and testing, were integrated into existing STI services for registered sex workers (sex work being legal in Senegal for women aged 21 years and older).

Today, prevention programs targeting FSW include communication for behavior change, training and peer education, HIV testing and counseling (HTC), distribution of male and female condoms, financial empowerment, and medical and biological monitoring. The program is implemented through management and follow-up in 36 fixed-location STI clinics and the use of mobile clinics specifically targeted for covert FSW³¹. There are currently 7,953 active FSW that are followed up by the FSW program, of whom 20% work covertly. Only 59% of FSW followed by the program have tested for HIV, and only 41% have tested for syphilis. In 2013 and 2014, more than two million male condoms and almost 60,000 female condoms were distributed to FSW³².

Cited program challenges include the unknown size of the FSW population outside Dakar, the focus on registered FSW while many work in a covert manner, the lack of equipment and testing reagents, the limited number of mobile clinics, and insufficient coverage of the program in border areas and weekly markets. In 2013, all HIV prevention programs targeting FSW were entirely financed by international sources³³.

Prevention programs for MSM include the support of a growing number of sites providing services specifically targeting MSM (43 sites in 2013, distributed across the country), the identification and training of service providers, support to associations of

The first cases of HIV were confirmed in Senegal in 1986 and the country has been recognized internationally for its timely and successful response to the epidemic and its continued efforts and commitment.

³¹ NACC. Rapport de situation sur la riposte nationale à l'épidémie de VIH/SIDA Sénégal: 2012–13. Suivi de la déclaration politique sur le VIH 2011

³² NACC/UNAIDS. Rapport de situation sur la riposte nationale à l'épidémie de VIH/SIDA, Sénégal, 2013–14.

³³ NACC, Senegal's National AIDS Spending Assessment (NASA), 2011–13

MSM, as well as identifying and educating MSM leaders (as peer supporters) and trainers. In addition, HIV and STI services for MSM are currently being integrated into the general health care in four sites (Kaolack, Mbour, Ziguinchor, and Sédhiou). Nevertheless, according to available programmatic data the coverage of MSM services is limited. In 2013, 1,958 MSM were followed up by the MSM program, of whom 1,720 individuals received prevention interventions. A total of 850 MSM were screened for HIV, and 330 tested HIV positive. Challenges include the fact that the true size of the MSM population is unknown, and insufficient training of healthcare providers to serve the needs of MSM. Stigmatization of MSM by healthcare workers has also been reported as a challenge. In 2013, all HIV prevention programs targeting MSM were entirely financed by international sources³⁴.

Prevention and treatment programs for drug users include outreach activities (promotion of low-risk behavior), distribution of injection kits, opioid substitution programs, serological tests, antiretroviral therapy and psychosocial support. In 2013, over 1,000 PWUD took part in these programs. Between November 2011 and November 2013, more than 18,000 clean syringes were distributed, and about 58% of used syringes were retrieved.

Challenges cited by the program include the restrictive legal environment, the stigmatization of PWUD, difficulties in targeting certain subpopulations (young and female PWUD), the absence of adequate information and communication resources, lack of training, and lack of financial resources. In 2013, all HIV prevention programs targeting PWUD were entirely financed by international sources³⁵.

In 2013, all HIV prevention programs targeting key populations (FSW, MSM and PWUD) were entirely financed by international sources.

Prevention programs aimed at the general population include HIV testing and counseling, communication for social and behavior change and condom promotion, with the latter also implemented using a social marketing strategy involving the private sector and covering all 14 regions of the country. In 2011, over 15 million condoms were distributed (excluding those sold commercially by the private sector). Activities promoting low-risk sexual behavior include the use of theater as a tool to foster debate on sensitive issues relevant to HIV transmission, such as sexual violence.

STI management for the general population is implemented in public and semi-public health care facilities. Etiological diagnoses are performed at regional and national reference laboratories. Serological screening for syphilis is integrated into the reproductive health services. A total of 35,373 syphilis tests were performed in 2013 (93% of these were carried out in women), revealing 1533 positive cases (90% in women). Overall, a total of 77,949 cases of STIs were reported in 2013. Cited challenges

³⁴ NACC, Senegal's National AIDS Spending Assessment (NASA), 2011–13

³⁵ NACC, Senegal's National AIDS Spending Assessment (NASA), 2011–13

in STI care include incomplete integration of STI education into the curricula of some educational institutions, shortages of some recommended drugs, lack of antibiotic resistance monitoring, incomplete notification of STIs at the site level, and incomplete data collection at the national level. In the future, the country is aiming to increase the coverage of syphilis screening among pregnant women, improve data management, integrate STI management and care into the private sector, and conduct more research on antibiotic resistance.

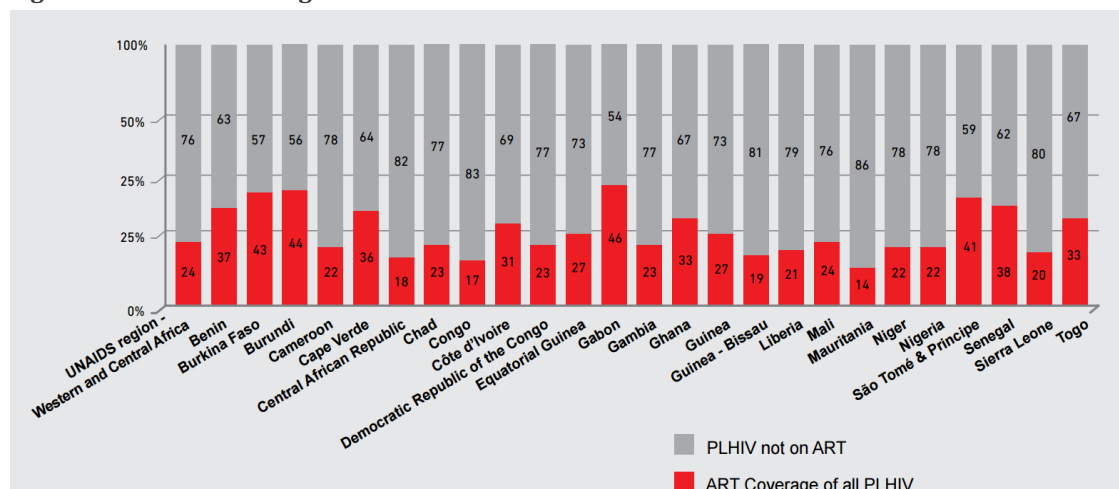
Senegal was the first country in Africa to subsidize treatment for HIV (1998), and by 2003 antiretroviral (ARV) drugs were provided free of charge. The country has consistently aligned itself with the World Health Organization's (WHO) recommendations relating to treatment eligibility, moving to a CD4 count threshold of 350 cells/mm³ in 2010 and to 500 cells/mm³ in 2014. The country is planning to pilot a test-and-treat policy targeting key populations in five regions. The number of patients starting ART annually has been increasing steadily: the number of people initiating ART more than doubled from 2074 in 2009 to 5086 in 2014³⁶. Despite this scale-up, coverage of ART is still low in both adults (38%) and children (15%) (according to WHO 2013 eligibility criteria). However, ART coverage is above the West and Central Africa average of 24%³⁷ (Figure 3.3), but below the global average of 46%³⁸. In 2014, 16,682 patients were receiving ART. Currently the country finances 70% of ART costs (through public financing) with the remaining 30% financed by international sources.

The country has consistently aligned itself with the World Health Organization's (WHO) recommendations relating to treatment eligibility, moving to a CD4 count threshold of 350 cells/mm³ in 2010 and to 500 cells/mm³ in 2014.

³⁶ Senegal Programmatic Data.

³⁷ Médecins Sans Frontières. Out of focus. How millions of people in West and Central Africa are being left out of the global HIV response. April 2016.

³⁸ World Health Organization. Global Health Observatory Data Repository. Antiretroviral therapy coverage, data and estimates by WHO region. 2015.
<http://apps.who.int/gho/data/view.main.23300REGION?lang=en>

Figure 3.3 ART coverage for countries in West and Central Africa

Source: UNAIDS, 2015 (cited in Médecins Sans Frontières, 2016³⁷).

Prevention of mother-to-child transmission (PMTCT) is also a priority for the country. All HIV-infected pregnant and breastfeeding women are eligible for free life-long ART (Option B+), though this is entirely funded by international sources. The country has significantly scaled up access to PMTCT services from four sites providing PMTCT services in 2002 to 198 sites currently providing PMTCT services countrywide including both HIV screening and treatment. This includes all hospitals and health centers, as well as some health posts. Despite this impressive scale up, only 53% of HIV positive pregnant women are on ART (only 38% in 2012) and prophylaxis is only accessed by 26% of children born to HIV positive pregnant women.³⁹

3.3 HIV/AIDS FINANCING

Senegal's high dependence on international HIV financing as well as the uncertainty over future financing means that Senegal may be at risk of losing the gains it has made in its successful fight against HIV/AIDS.

The total annual spending on HIV/AIDS programs in 2013 was 24 million US dollars⁴⁰ (Table 3.1). However, the country relies heavily on international financing for its HIV/AIDS response with the majority of the investments (USD 17.4 million, 72%) coming from international donors. Domestic public spending was USD 4.8 million (20%), and private spending (mainly household contributions) USD 1.8 million (8%). The main international donor is the Global Fund, which provided USD 10.2 million in 2011 (59% of all international funding, and 42% of all spending). The remaining funding was mainly bilateral, with the United States government being the largest contributor, covering a 19% share of the total spending⁴⁰.

³⁹ Global Fund Concept Note, 2015–17.

⁴⁰ NACC, Senegal's National AIDS Spending Assessment (NASA), 2011–13, conversion rate 1USD = 500CFA.

Table 3.1 Key statistics on HIV spending, 2013

Total HIV spending in 2013	USD 24.0 million
HIV spending by source	USD x million (%)
International	17.4 (72.3%)
Global Fund	10.2 (42.4%)
U.S. Government	4.6 (19.0%)
Direct bilateral other than U.S. Government	0.9 (3.6%)
Other international funding	1.8 (7.3%)
Domestic public	4.8 (20.1%)
Private	1.8 (7.6%)
Household contributions	1.7 (7.0%)
Non-profit organizations	0.1 (0.6%)
Total HIV spending as a share of GDP	0.16%
Total HIV spending per capita, USD	1.70
Total HIV spending per person living with HIV, USD (based on 2013 expenditure and Spectrum estimate for PLHIV)	545.00

Source: Authors

Domestic public funding has remained fairly stable between 2007 and 2013 (Figure 3.4)^{40, 41}. Contributions from private sources were also relatively stable until 2011 but halved from USD 3.6 million in 2011 to 1.8 million in 2013. The major change in the international funding between 2007 and 2013 has been the increasing role of The Global Fund to Fight AIDS, Tuberculosis and Malaria (Global Fund). In 2008, the U.S. government was still the largest individual international donor, providing 29% of the total funding, whereas the Global Fund accounted for 23% of all funding. By 2011, the share of the Global Fund had grown to over 50% of the national HIV response. However, between 2012 and 2013, the spending from the Global Fund resources decreased by 26%. This together with the drop in domestic private funding between 2011 and 2012 (from USD 3.6 million to USD 1.8 million) have led to a clearly decreasing trend in the total amount of funding for the HIV response in Senegal⁴⁰. In addition, Global Fund financing has only been secured until 2017⁴².

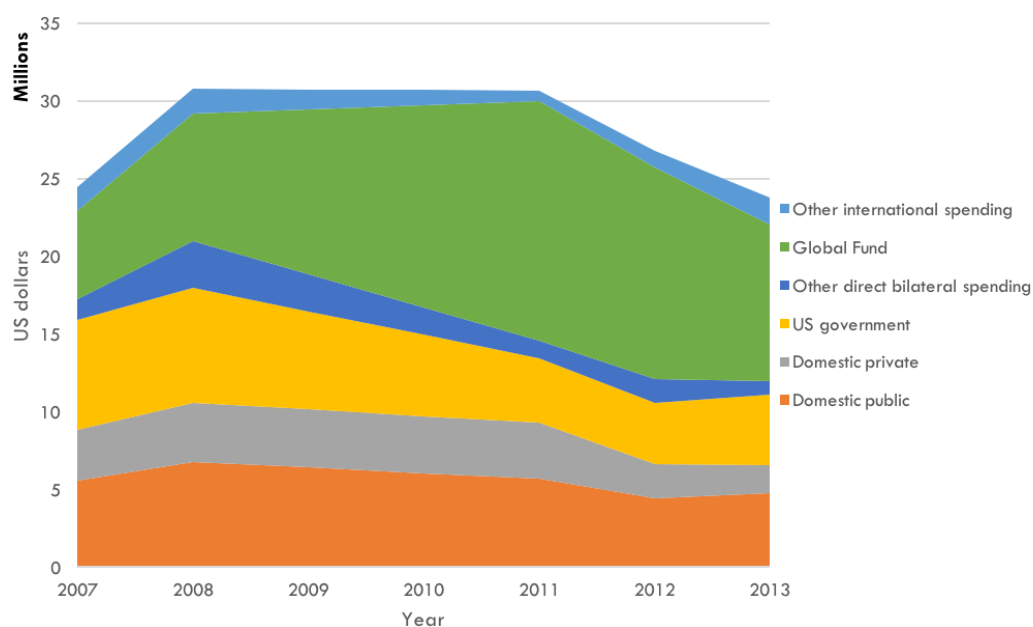
In terms of allocation of financial resources, there are several important observations and trends to note. In 2013, a significant proportion of the HIV budget was allocated to management and administration (33% versus 27% in 2011), treatment and care (31% versus 20% in 2011), and prevention (25% versus 43% in 2007). The rest of the budget in 2013 was allocated to programs encouraging a favorable environment (4% versus 2% in 2011), programs for Orphans and Vulnerable Children (OVC) (4% versus <1% in 2011), human resources (2% versus 7% in 2011), HIV research excluding operational research (1% versus 0% in 2011) and social protection and social services (0.2% in

⁴¹ NACC, Senegal's National AIDS Spending Assessment (NASA), 2007–08.

⁴² Global Fund Concept Note, 2015–17.

2011 and 2013)⁴⁰. Figure 3.5 provides an overview of expenditures by program for 2013. Table 3.2 summarizes the source of financing for HIV programs.

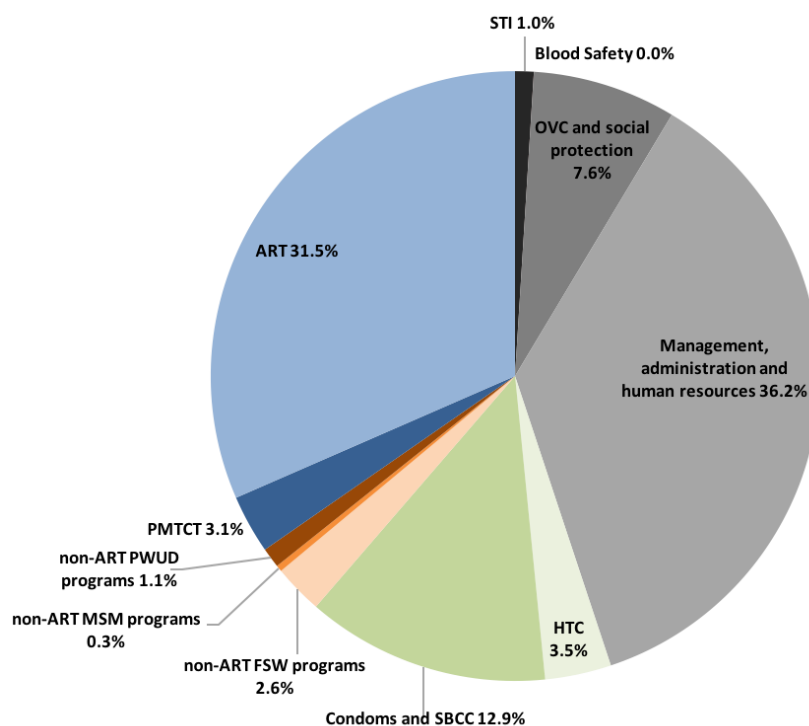
Figure 3.4 Domestic and international HIV spending in Senegal, 2007–13



Source: NASA 2007–08 and NASA 2011–13.

Note: No data were available for 2009 and 2010.

Figure 3.5 Senegal's HIV expenditures by programs, 2013



Source: NASA, 2013.

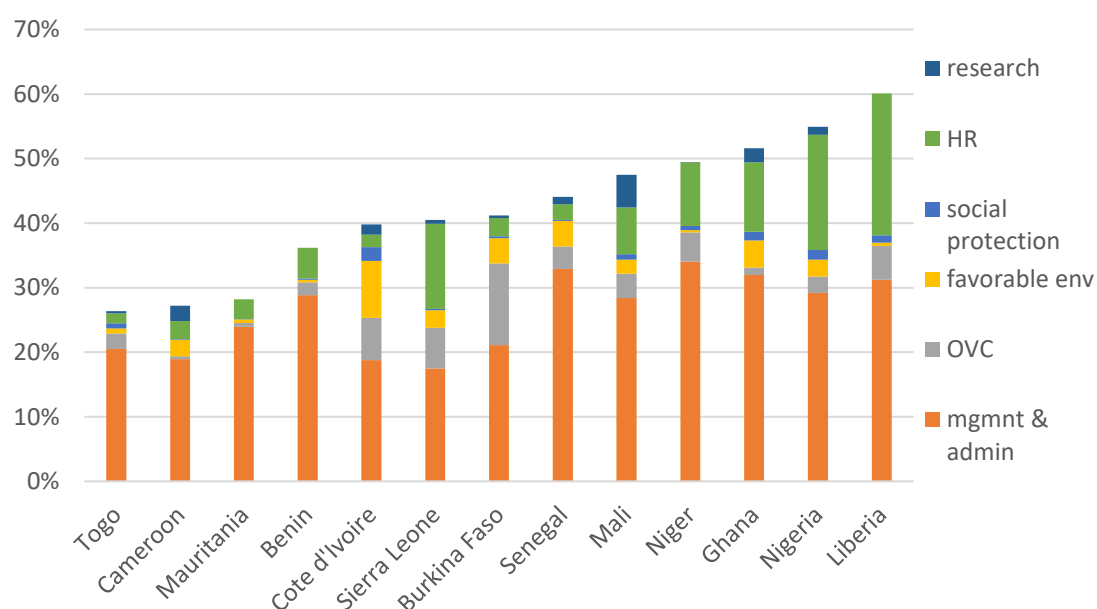
Table 3.2 Senegal HIV program financing by source

	Domestic public	Domestic private	International spending
Condoms and SBCC	0.0%	4.4%	95.6%
non-ART FSW programs	0.0%	0.0%	100.0%
non-ART MSM programs	0.0%	0.0%	100.0%
non-ART PWUD programs	0.0%	0.0%	100.0%
HTC	0.0%	0.0%	100.0%
PMTCT	0.0%	0.0%	100.0%
ART	41.5%	20.4%	38.2%
OVC and social protection	0.0%	0.1%	99.9%
STI	0.0%	0.0%	100.0%
Blood Safety	0.0%	0.0%	100.0%
Management, administration and human resources	19.4%	1.7%	78.9%

Source: NASA, 2013

HIV/AIDS financing – comparison with other West African countries

Figure 3.6 compares indirect program spending for West African countries.

Figure 3.6 Proportion of the budget spent on indirect programs in West African countries

Source: The most recent (2008–13) NASA report for each country, <http://www.unaids.org/en/dataanalysis/knownyourresponse/nasacountryreports>.

Programs that do not have a direct impact on HIV transmission or HIV-related mortality or have impact beyond HIV programs are defined as ‘indirect programs’. In other words, it is unclear what impact scaling an indirect program up or down will have on HIV incidence or HIV-related mortality. Examples of indirect programs include management

and administration, social protection and research, among others. These programs cannot be optimized in Optima directly. While in the main analysis we assume that the funding for indirect programs needs to stay constant to support the direct programs, in a sub-analysis we include some of the indirect program costs into Optima by assuming the programs could make savings (e.g., management becoming more efficient), and the saved money could be used for direct programs, which would effectively increase the funding that is available for optimization (more detail can be found in Section 4.3).

The data shown in Figure 3.6 represent the most recent NASA report for each country (between 2008 and 2013). The share of indirect programs (as a proportion of the total HIV/AIDS budget) ranged between 26% (Togo) and 60% (Liberia). With 44%, Senegal's share of the total budget spent on indirect programs was close to the West African average (42%). However, it had the second highest spending on management and administration (33% of its total budget), second only to Niger (34%) (regional average in West Africa was 26%).

Section 4

METHODOLOGY

To assess HIV epidemic trends, we used Optima's HIV epidemic model, which consists of a mathematical model of HIV transmission and disease progression. Optima uses best-practice HIV epidemic modeling techniques and incorporates evidence on biological transmission probabilities, detailed infection progression, sexual mixing patterns and drug injection behaviors. Optima was calibrated to HIV prevalence data points available from the different sub-populations (e.g., female sex workers, men who have sex with men, drug users), as well as to data points on the number of people on ART, in consultation with local experts in Senegal.

To assess how incremental changes in spending affect the HIV epidemic and determine the optimal funding allocation, the model parameterizes relationships between the cost of HIV intervention programs, the coverage level attained by these programs and the resulting outcomes. These relationships are specific to the country, population and prevention program being considered.

Using the relationships between cost, coverage and outcome in combination with Optima's HIV epidemic model, it is possible to calculate how incremental changes in the level of funding allocated to each program will impact overall epidemic outcomes. Furthermore, by using a mathematical optimization algorithm, Optima is able to determine the 'optimal' allocation of funding across different HIV programs. Further details about Optima can be found here: <http://www.optimamodel.com>

Optima was calibrated to HIV prevalence data points available from the different sub-populations (e.g., female sex workers, men who have sex with men, drug users), as well as to data points on the number of people on ART, in consultation with local experts in Senegal.

4.1 ANALYTICAL FRAMEWORK

One of the first steps of the modeling procedure was to select the relevant input parameters for the Optima model in Senegal. These include the population groups, programs (expenditure areas), and baseline scenarios and funding. Expenditure areas can either be included in the optimization or have fixed costs. The parameters to be included in the model were defined in discussions between representatives of the World Bank, University of Bern, and UNAIDS as well as Senegal stakeholders (including

Government) and Optima team members at the University of New South Wales (UNSW) and Burnett Institute, and are summarized in the following table (Table 4.1).

Table 4.1 Input parameters for the Optima Model

Category	Parameterization in the Optima Model	
Populations defined in the model	<ul style="list-style-type: none"> - Children (0–14 years) - Young women (15–24 years) - Young men (15–24 years) - Adult women (25–49 years) - Adult men (25–49 years) - Older women (50+ years) - Older men (50+ years) 	<ul style="list-style-type: none"> - Female sex workers (FSW) - Mobile populations and clients of sex workers (higher-risk men) - Men who have sex with men (MSM) - People who use drugs (injecting and non-injecting) (PWUD)
Programs (Expenditure areas) defined in the model and included in the optimization analysis	<ul style="list-style-type: none"> - Targeted non-ART prevention services for FSW (incl. condoms, HTC and excluding ART) - Targeted non-ART prevention services for MSM (incl. condoms, HTC, and excluding ART) - Targeted non-ART prevention services for PWUD (incl. needles, condoms, HTC, and excluding ART) 	<ul style="list-style-type: none"> - Condom promotion for the general population and Social and Behavior Change Communication (SBCC) - HIV testing services for the general population (HTC) - PMTCT - ART (including first and second line treatment and other HIV-related patient care, nutritional support associated with ART, psychological support, laboratory monitoring - all population groups)
Programs (Expenditure areas) not included in optimization (program impact on HIV incidence and morbidity and mortality not understood and/or allocation cannot be reduced e.g., due to ethical reasons)	<ul style="list-style-type: none"> - Programs for orphans and vulnerable children, favorable environment and social protection (collectively referred to as 'OVC' in the modelling) 	<ul style="list-style-type: none"> - Blood safety - STI - Management and human resources
Time frames	<ul style="list-style-type: none"> - 2014–17 (2013 baseline) - 2014–20 (2013 baseline) 	<ul style="list-style-type: none"> - 2014–30 (2013 baseline)
Baseline scenario/counterfactual HIV epidemic projection	<ul style="list-style-type: none"> - The baseline scenario is an epidemic projection produced by Optima assuming constant spending (2013 expenditure) and allocation of this envelope across programs as per the 2013 distribution. 	<ul style="list-style-type: none"> - The epidemic and financial impact of the above scenario is used as a counterfactual to measure the impact on new HIV infections and deaths as well as savings with optimal allocations.
Baseline scenario funding (2013 NASA year)	<ul style="list-style-type: none"> - USD 24.0 million (programmatic spending, including indirect programs) 	

Source: Authors

4.2 MODEL CALIBRATION

As part of the model validation process, calibration was done to align Optima projected trends in HIV prevalence with historically observed trends in HIV prevalence in different population groups. Please refer to Annex 3, Model Calibration Results for additional details on the model calibration.

4.3 PROGRAM DATA: COST-COVERAGE-OUTCOME RELATIONSHIPS

The relationship between program spending and coverage describes the level of output (availability of a service to a specific proportion of the target population or coverage) achieved with a specific level of financial input (cost). For example, this relationship would describe how many female sex workers can be provided with a standard package of services with an investment of 0 to 1,000,000 USD. The relationship between coverage and outcome describes the proportion of people who will adopt a specific behavior (such as condom use or consistent use of ART leading to viral suppression) in relation to the program coverage.

4.3.1 PROGRAM COVERAGE

Table 4.2 provides the definitions used to define coverage and the assumed coverage (based on the reported number of people served from reported program coverage data) used for each program included in the modeling analysis.

Table 4.2 Program coverage, 2013

Program	Definition of coverage	Assumed coverage in 2013
FSW non-ART HIV prevention	% FSW who received condoms and know a place to get an HIV test	84%
MSM non-ART HIV prevention	% MSM who received condoms and know a place to get an HIV test	76%
PWUD non-ART HIV prevention	% PWUD who received condoms, received clean needles, and know a place to get an HIV test	30%
HTC	% adults in general population (excluding the key populations FSW, MSM and PWUD) who got tested for HIV in the last 12 months	3%
ART	% PLHIV eligible for treatment receiving treatment	38%
PMTCT	% pregnant HIV-positive mothers receiving ART for preventing mother-to-child transmission ("Option B+")	51%
Condoms and SBCC	% adults in the general population (excluding the key populations FSW, MSM and PWUD) who received condoms in the last 12 months	5%

Source: Authors

4.3.2 PROGRAM COST

Program expenditure was derived from Senegal's National AIDS Spending Assessments (NASA), which have been carried out for the years 2007, 2008, 2011, 2012 and 2013. Using these data as well as outcome data (such as HIV testing rate for HTC programs, condom use per population for condom promotion programs, number of people on ART for ART programs etc.) we developed cost-outcome curves that define the relationship between program expenditure and respective outcomes. It is important to note that the relationship between spending and outcome does not need to be linear. We can include a saturation effect with increased spending. The cost-outcome curves are shown in Annex 2. These cost-outcome curves allowed us to derive unit costs for each program; this top-down costing approach derives unit costs from expenditure and coverage data (Table 4.3). When the coverage data for a specific year were missing, we used the estimated unit costs cited in UNAIDS' Fast Track Strategy in Senegal⁴³. We compared the unit costs we derived using NASA expenditure data and coverage with UNAIDS' unit costs and found that they were similar. The only clear difference was for PMTCT, where the unit cost we derived from NASA (USD 461.41) was considerably higher than the cost cited by UNAIDS (USD 152.28). This is because our cost estimates for PMTCT included the cost of screening the average number of ANC clients to identify one HIV-positive client, and subsequent provision of the PMTCT service package to this expectant mother (rather than just the cost of providing the PMTCT service package to HIV-positive expectant mothers as is the case for the UNAIDS unit cost estimates).

Table 4.3 Unit costs for different programs

Program	Unit costs in USD
Targeted non-ART prevention services for FSW (incl. condoms, HTC outreach)	32.28
Targeted non-ART prevention services for MSM (incl. condoms, HTC outreach)	55.78
Targeted non-ART prevention services for PWUD (incl. condoms, HTC outreach)	65.81
Services for the general population – HTC	4.73
Services for the general population – Condoms and SBCC	5.86
Prevention of mother-to-child transmission (per woman living with HIV identified and provided with PMTCT)*	*152.28 **461.41
ART incl. first-line drugs and second line drugs	523.00

Source: Authors

Notes: *Based on NASA 2013, including testing for HIV- women; **Cited from UNAIDS Fast Track.

We call programs that do not directly influence HIV epidemics, whose impact is not known, and that have wider societal benefits beyond HIV/AIDS 'indirect programs'. The indirect programs included in the model are:

- Management (including human resources (HR), research, infrastructure)
- OVC (including social protection and favorable environment)

⁴³ 'UNAIDS' Fast Track Strategy: Country Specific Targets, 2015

- Blood safety (as per NASA 2013, only a minor part of the blood safety spending in Senegal)
- STI

We do not include these programs in the optimization of the primary analysis i.e., we assume the spending for these programs remains constant. We consider one additional optimization scenario, in which spending for program coordination and planning is reduced by 25% (the total spending for management is decreased by 16.8%) and other indirect programs are funded from a different source. We assume that these changes have no impact on the relevant program outcomes.

4.4 SCENARIO ANALYSES

We used the Optima model to analyze the influence of different scenarios on the projected future trajectory of the country's HIV epidemic. In the baseline scenario, all aspects of HIV-related behavior (e.g., condom use, PMTCT, ART, use of new syringes etc.) were kept constant at the 2013 level. We assumed that program coverage scale-up or scale-down is achieved by 2017 or 2020 depending on the specific scenario in question. Similarly, the timelines for measuring the epidemic trajectories used were 2017 (end of the current NSP period), 2020 and 2030, depending on the specific scenario in question. The following scenarios were analyzed:

a. Investments in specific programs

- What is the projected future trajectory of Senegal's HIV epidemic if programs for key populations (female sex workers, men who have sex with men and people who use drugs) are defunded? Defunding is assumed to decrease condom use, use of clean syringes among PWUD and HIV testing rates by 50%
- Program scale-down is assumed to occur between 2014 and 2017

b. Attaining program-specific NSP coverage targets

- What is the projected future trajectory of Senegal's HIV epidemic if, by 2017 (end of the current NSP period), the proportion of HIV-positive pregnant women receiving antiretroviral therapy (ART) for prevention of mother-to-child transmission (PMTCT) increases to 90% (from 51%)?

c. Attaining the global 90/90/90 targets

- What is the projected future trajectory of Senegal's HIV epidemic if, by 2020, 90% of all people living with HIV know their HIV status, 90% of all people with diagnosed HIV infection receive sustained antiretroviral therapy and 90% of all people receiving antiretroviral therapy have viral suppression?

d. Policy change regarding treatment eligibility

- What is the projected future trajectory of Senegal's HIV epidemic if the country implements a universal test-and-treat strategy?

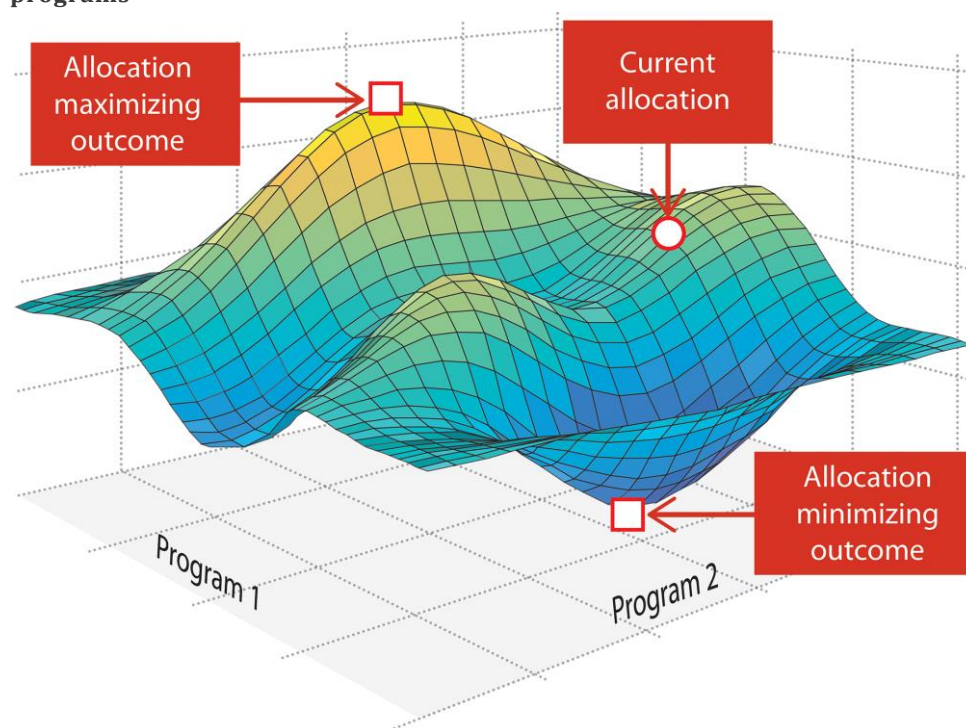
Note that under current Senegal guidelines, all people living with HIV with a CD4 count of <500 cells/mm³ are eligible for ART. In addition, new guidelines are to implement a test-and-treat strategy for key populations in five regions. A test-and-treat strategy involves the initiation of ART to all people testing HIV positive, regardless of baseline CD4 count.

4.5 OPTIMIZATION

The mathematical optimization provided by the Optima model is a formal and precise way to determine the 'best' allocation. In this process, different objectives (e.g., minimize HIV incidence, minimize HIV costs) result in optimal allocations of resources or spending. The model determines the resource allocation required that best meets the specified objective. Figure 4.1 is a graphical depiction of this process.

The mathematical optimization provided by the Optima model is a formal and precise way to determine the 'best' allocation.

Figure 4.1 Graphical illustration of an optimal allocation of resources between two programs



Source: Optima

4.6 LIMITATIONS OF THE ANALYSIS

4.6.1 LIMITATIONS SPECIFIC TO SENEGAL

Limited/Scarce data

The key data limitation encountered was the lack of national level population size estimates for key populations. We used estimates from surveys conducted mainly in Dakar and projected these nationally. We estimated the total population size of FSW to be 28,920 (4200 in Dakar) and the population size of MSM to be 12,304 (1840 in Dakar) for the year 2012. These estimates were similar to those provided by UNAIDS' Country Specific Targets as part of the 'Fast Track Strategy'⁴⁴. In addition, the calibration of the model had very few data points available on the HIV prevalence level in each of the chosen populations overall. There was also a lack of data on historical program spending, and little information to associate program spending to impact or performance. The unit costs and coverage of different programs are also not directly comparable with each other as different methods and types of data sources were used to estimate these; for example, we sometimes had to use UNAIDS' estimated unit costs⁴⁵ (when program coverage was unknown) while for other programs unit costs were directly calculated using program spending and program coverage data. Some populations of interest could not be included as separate groups in the analysis due to lack of data. This includes populations of humanitarian concern, such as prisoners and migrants. In addition, the impact of programs on HIV outcomes was not always clear, particularly in the case of programs influencing behavior such as condom use or the use of clean syringes.

Migration effects

There is limited data available on the effects of migration (both within Senegal, and between Senegal and neighboring countries). The significant differences in HIV prevalence between Senegal and its neighbors could potentially influence the analysis.

4.6.2 LIMITATIONS OF THE MODELING METHODOLOGY

The modeling methodology itself also had several limitations:

- In our approach, all changes in behavior are assumed to be due to changes in program funding which change coverage of programs among targeted populations. This assumption is common in epidemic models.
- The analysis uses past ratios of expenditure to coverage as a basis for determining program cost rather than unit costs. This approach of using past cost and results has a number of advantages over using projected costs from plans and budgets, which are ultimately predictions of future cost. Nevertheless, one disadvantage to using past ratios of expenditure to coverage rather than unit

⁴⁴ UNAIDS. 2015. Fast Track Strategy. Country Specific Targets, Senegal.

⁴⁵ UNAIDS. 2015. Fast Track Strategy. Country Specific Targets, Senegal.

costs is that there may be future increases or decreases in cost in relation to new approaches, implementation arrangements or technologies.

- The modeling approach we used to calculate the relative cost-effectiveness between programs is not based on direct causal relationships, but instead on unit costs, observed ecological relationships between outcomes of program coverage or risk behavior and the amount of money spent on programs in the past.
- The analysis did not determine the technical efficiency of programs as this was beyond the scope of the analysis. However, gains in technical efficiency would decrease unit costs and therefore affect optimal resource allocation.
- Effects outside the HIV endpoints are not considered (e.g., wider effects of PMTCT within Mother and Child Health (MCH) programs, of condom use as a contraceptive, or effects of sex work interventions on STIs and Sexual and Reproductive Health).
- Our approach does not consider equity or quantification of human rights, stigma and discrimination, ethical, legal or psychosocial implications.
- Other models may produce different projections than those produced by Optima. However, our model's predictions were similar to Spectrum-predicted trends.

Section 5

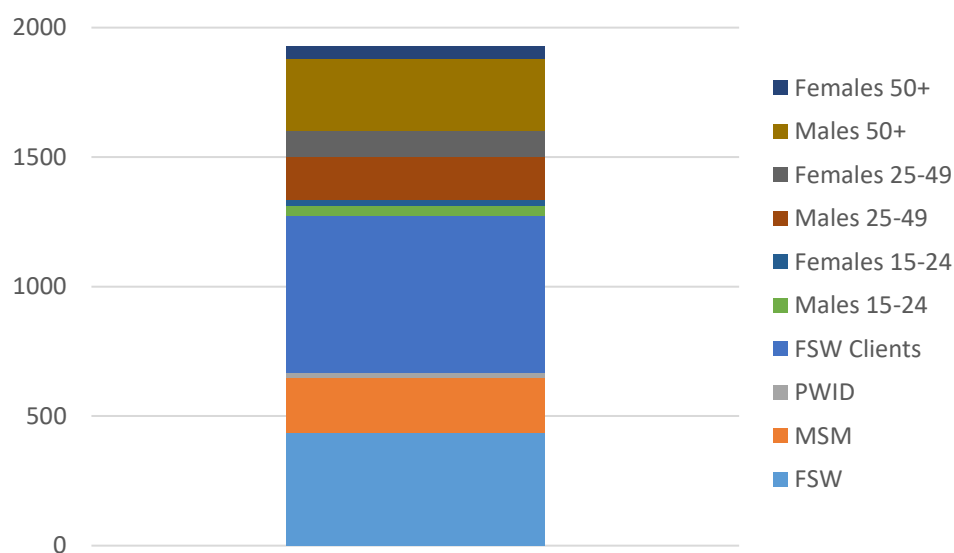
RESULTS

5.1 HIV TRANSMISSION DYNAMICS

Because of Senegal's early and significant investment in HIV prevention and treatment, if Senegal continues to invest in its HIV response in the same manner that it does today (total financing and allocation of budget across programs), HIV infections and AIDS deaths will continue to decline.

The Optima model estimated a total of 2,500 new infections and 2,200 HIV-related deaths to have occurred in 2014. Of the 2500 new infections acquired, 14.1% were predicted to occur among FSW, 16.8% among FSW clients and the mobile population, 5.3% among MSM, 0.5% among drug users, 22.4% among children, 0.1% and 8.2% among male and female youth respectively, 6.9% and 19.4% among males and females aged between 25 and 49 years, respectively, and 0.5% and 5.8% among males and females aged 50 years and older, respectively. While the majority of new infections are acquired by children and women aged between 25 and 49 years (due to the relatively larger population sizes), the majority of new HIV infections (53.8%) are transmitted as a result of sex work (from sex workers and their clients to the low-risk female population) (Figure 5.1). HIV incidence in 2014 was clearly higher among the key populations (1.54, 1.35 and 0.55 per 100 person years for FSW, MSM and PWUD respectively) than among the overall population (0.03 per 100 person years).

Figure 5.1 Infections transmitted by population group, 2014



Source: Authors

Assuming that all programs receive the same funding as in 2013 (total USD 24 million) each year until 2030:

- An estimated 2200 new infections and 2000 HIV-related deaths would occur in the year 2029, representing 8.7% and 9.0% reduction in the annual numbers of new HIV infections and deaths, respectively (Figure 5.2).
- By 2030, there will be an estimated 38,700 persons living with HIV (compared to an estimated 41,400 in 2014).

Figure 5.2 A) Projection of the number of new HIV infections in different population groups (2000–30); B) Projection of the number of HIV-related deaths in different population groups (2000–30)

Figure 5.2A

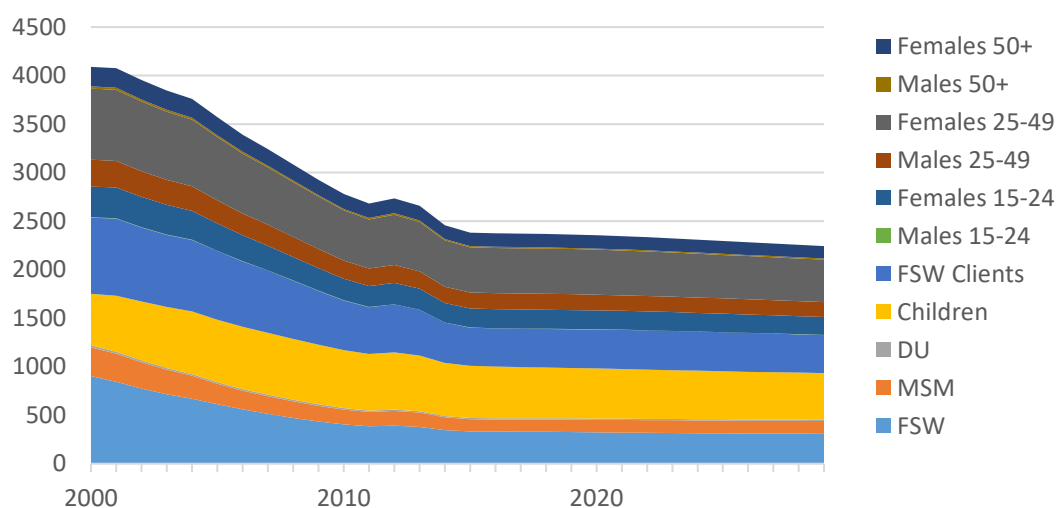
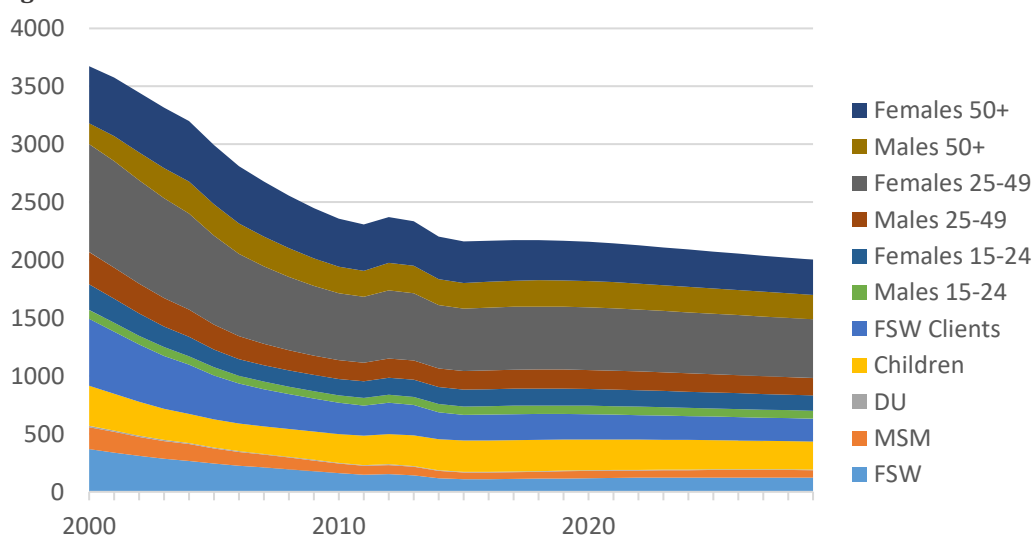


Figure 5.2B



Source: Authors

5.2 ACHIEVING THE NATIONAL STRATEGIC PLAN TARGETS

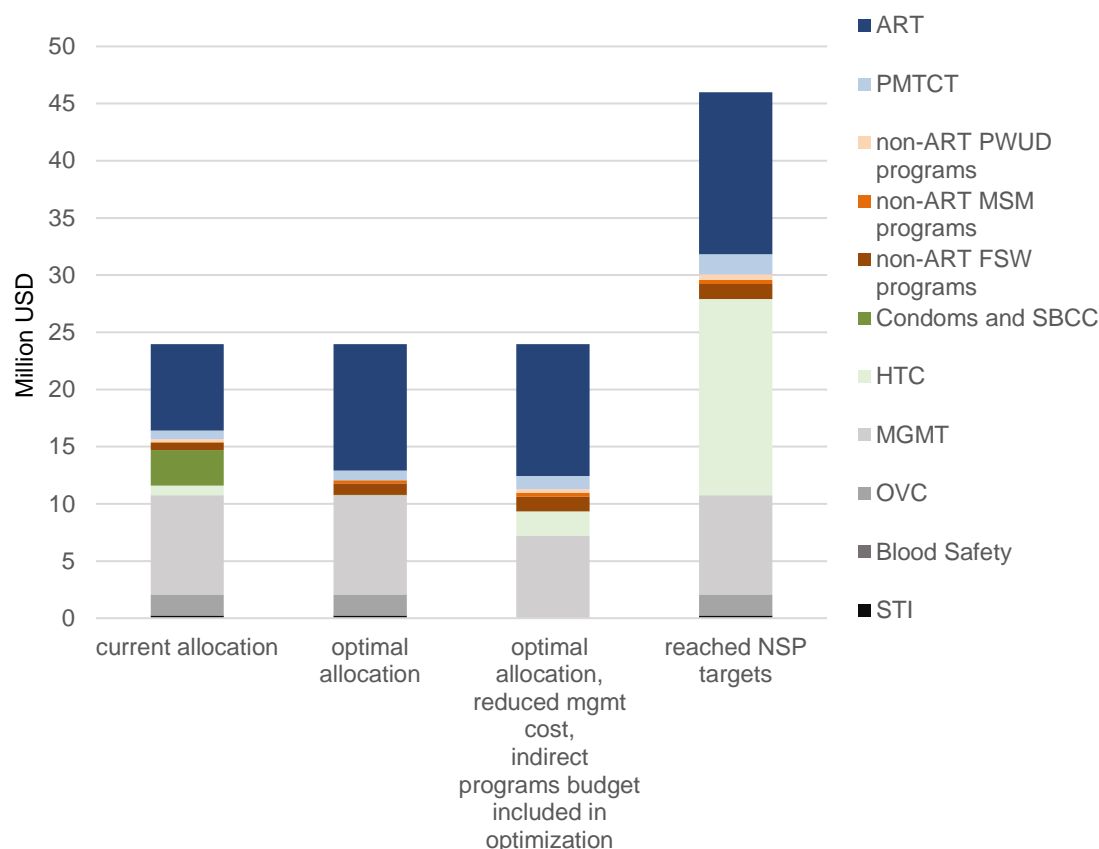
While Senegal's investments and efforts through the implementation of its National HIV Strategic Plan will have a considerable impact on the HIV epidemic, the country could attain an even higher impact by having a more optimal allocation of resources (for the same amount of resources). In order to reach the NSP targets of reducing both new HIV infections and HIV-related deaths by 50%, it would be necessary to invest an additional USD 22 million per year; that is, approximately double the current annual HIV expenditure. With the current budget, it is possible to reduce new HIV infections by 49.3% (close to NSP impact target of 50%) and to reduce HIV related deaths by 31% (not close to the NSP impact target of 50%).

Senegal's current National Strategic Plan covers the period 2014–17 and has an impact goal of reducing the number of new infections and HIV-related deaths by 50% by 2017. There were approximately 2,700 new infections and 2,300 HIV-related deaths in 2013. With the current budget available for optimization (annual average of 24 million US dollars) and current allocation across programs and populations, Optima estimates that the number of new HIV infections would decrease to 2,300 and the number of HIV-related deaths to decrease to 2,200 in 2017. If the same budget was allocated optimally, the number of new infections in 2017 would be 1,300 and number of deaths 1,600. This means that:

- Current investments with current allocation are estimated to reduce the number of new HIV infections in 2017 by 14.8% and reduce the number of HIV-related deaths by 4.3% compared to 2013.
- If this current budget was allocated optimally (please see Figure 5.3 for the current and optimal allocations), the number of new infections would decrease by 900 (49.3%), and the number of HIV-related deaths by 550 (31%) compared to the 2013 baseline. The impact on new HIV infections and deaths by population group are shown in Figure 5.4 and Figure 5.5. This means that with the same budget, but allocated optimally, Senegal could almost reach its NSP impact target of reducing new HIV infections by 50% and make a significant step towards reaching its second impact target of reducing HIV-related deaths by 50%.
- If the management of the HIV program could be made more efficient and OVC (including social protection) and blood safety programs were funded from other sources, the budget available for direct HIV prevention and treatment programs would increase by over USD 3.5 million each year. It would allow to reduce the number of new HIV infections by 980 (52%) and the number of HIV related deaths by 620 (34%) by 2017 compared with 2013.
- In order to reach the NSP targets, an additional USD 22 million per year would be required. The funding for PMTCT, FSW non-ART prevention programs, PWUD non-ART prevention programs and ART (for all) should be doubled compared

with the current spending. Funding for MSM non-ART prevention programs should be increased 4-fold. Extensive testing would also be required: spending for HTC should be 20-fold higher than current spending. The allocation that would allow to reach the NSP targets is presented in Figure 5.3 and Table 5.1.

Figure 5.3 Current, optimal and reaching NSP target allocation for the 2014–17 period



Source: Authors

Table 5.1 Current and optimal allocation of the current budget and the budget needed to achieve NSP targets

	Current allocation		Optimal allocation		Optimal allocation (reduced management costs, indirect programs' budget included in optimization)*		Budget increased and allocated optimally to achieve NSP targets	
	USD	%**	USD	%**	USD	%**	USD	%**
STI	237,530	1.0%	237,530	1.0%		0.0%	237,530	0.5%
Blood Safety	890	0.0%	890	0.0%		0.0%	890	0.0%
OVC	1,827,885	7.6%	1,827,885	7.6%		0.0%	1,827,885	4.0%
MGMT	8,694,642	36.3%	8,694,642	36.3%	7,237,099	30.2%	8,694,642	18.9%
PMTCT	744,230	3.1%	838,368	3.5%	1,136,780	4.7%	1,770,379	3.8%

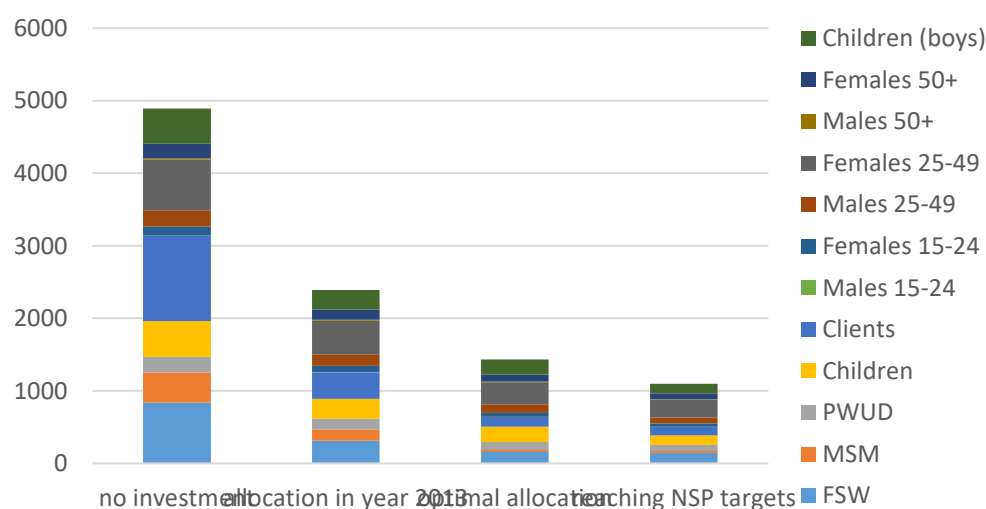
Table 5.1 Current and optimal allocation of the current budget and the budget needed to achieve NSP targets (continued)

	Current allocation		Optimal allocation		Optimal allocation (reduced management costs, indirect programs' budget included in optimization)*		Budget increased and allocated optimally to achieve NSP targets	
	USD	%**	USD	%**	USD	%**	USD	%**
Condoms and SBCC	3,099,189	12.9%	6,128	0.0%	36,948	0.2%	5,506	0.0%
non-ART FSW programs	627,290	2.6%	1,002,339	4.2%	1,263,651	5.3%	1,313,791	2.9%
non-ART MSM programs	79,511	0.3%	286,704	1.2%	350,568	1.5%	360,117	0.8%
non-ART PWUD programs	254,241	1.1%	18,859	0.1%	316,743	1.3%	470,983	1.0%
HTC	844,735	3.5%	8,150	0.0%	2,082,665	8.7%	17,144,610	37.3%
ART	7,558,313	31.5%	11,048,962	46.1%	11,545,003	48.2%	14,173,668	30.8%
Total	23,968,456	100.0%	23,970,456	100.0%	23,969,457	100.0%	46,000,000	100.0%

Source: Authors

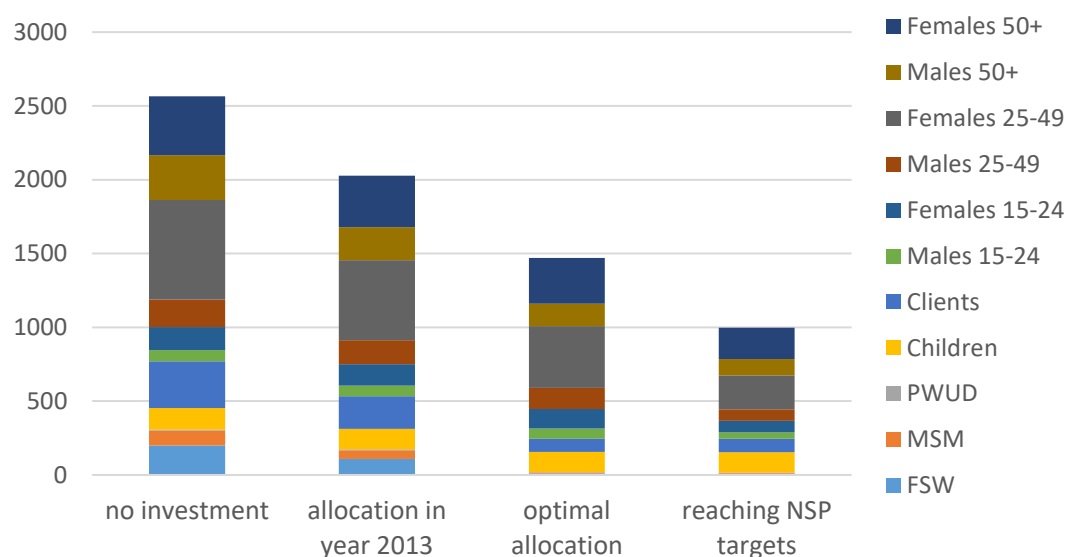
Notes: * Management costs are reduced by 16.8% (representing a 25% reduction in the budget for planning and coordination). Blood safety and OVC are assumed to be funded from other sources, as these are not HIV specific programs, and they are needed in the country regardless of the HIV epidemic. The saved money is made available for optimization and reallocated to the direct programs;

**Proportion of total budget.

Figure 5.4 The projected impact on the number of new HIV infections with no investments, current allocation of NSP budget, optimal allocation of NSP budget and the allocation allowing to reach NSP targets

Source: Authors

Figure 5.5 The projected impact on the number of HIV-related deaths with no investments, current allocation of NSP budget, optimal allocation of NSP budget and the allocation allowing to reach NSP targets



Source: Authors

5.3 BEST RESOURCE ALLOCATION FOR MAXIMUM LONG-TERM IMPACT

For maximum long-term impact HIV financial resources should be shifted from non-ART prevention programs targeting the low-risk general population to the scale-up of treatment (for the general and key populations) while maintaining resources for non-ART prevention programs targeting FSW.

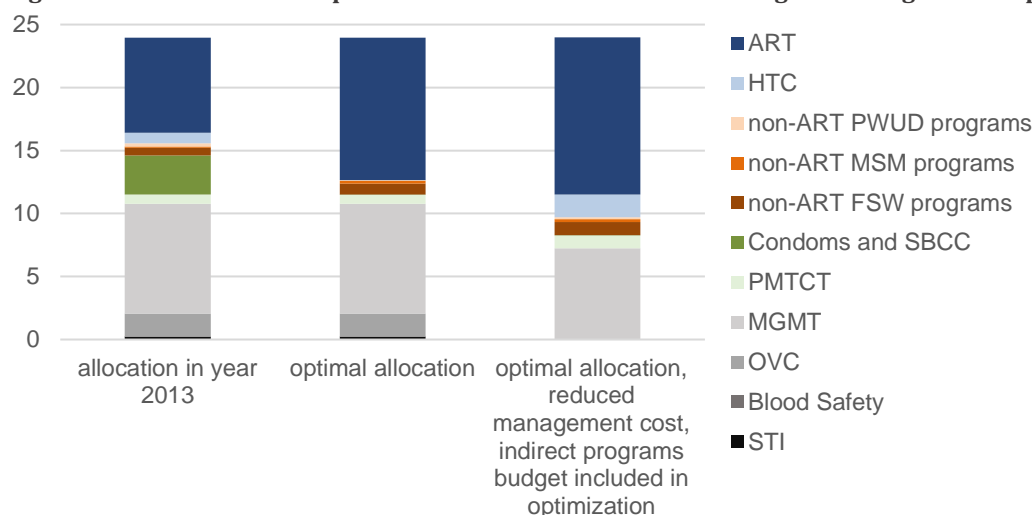
One of the key aims of this analysis was to determine the optimal allocation of current HIV financial resources (24 million U.S. dollars per year) for the period 2014-2030 to minimize the total number of new HIV infections and AIDS-related deaths during the same time period (2014–30; to capture the longer term benefits of investment). To answer this question, we used Optima's optimization algorithm, which uses information on the relationship between costs and outcomes of each programs (Annex 2, Cost-coverage curves).

Compared to the 2013 spending pattern, minimizing HIV incidence and HIV-related mortality until 2030 would require prioritizing the scale-up of ART for all populations, while maintaining resources for non-ART HIV prevention programs targeting the key drivers of the epidemic, particularly FSW. This means that financing for non-ART prevention programs targeting the low-risk general population needs to be reduced (see Figure 5.7 and Table 7 for the current allocation and the optimal allocation). In addition, funding for non-ART prevention programs for PWUD is not as high priority with the current resources available and therefore would optimally receive less funding, but this group would benefit from increased ART coverage. Specifically:

- Spending on ART (general population and key populations) should be increased from circa 31.5% to circa 47.2% of the budget
- Spending on non-ART prevention programs targeting FSW should increase from 2.6% to 3.5% of the budget
- Spending on non-ART prevention programs targeting MSM should be increased from 0.3% to 1.0% of the budget
- Spending on non-ART prevention programs targeting drug users (injecting and non-injecting) should be reduced from 1.1% to less than 0.2% of the budget. Note that this is likely due to the small proportion of drug users that inject (14%), i.e., the majority of the financing is currently targeted to non-injecting drug users
- Condom promotion and SBCC (including non-specified prevention) targeting the low-risk general population should be reduced from circa 12.9% to less than 0.1%
- While PMTCT is not prioritized in an optimal allocation (as children born during the modeled 16-year period would rarely transmit HIV infection during this time period), due to the ethical importance of PMTCT, as well as the potential long-term benefits, it would be recommended to maintain HIV financing for this program. It is also important to note that 22% of all new HIV infections are estimated to occur among children. In addition, while HTC for the general low-risk population is not prioritized with the current budget, HTC for key populations are included in the respective key population program and is therefore prioritized. Furthermore, not all newly diagnosed HIV positive patients are initiated on ART—due to the current eligibility criteria (not test and treat) and/or relatively poor coverage of ART. In other words, in the context of relatively low ART coverage, an optimal allocation may prioritize the scale up of ART before it prioritizes the diagnosis of additional HIV positive persons. If the budget increases, however, HTC should be scaled up along with ART (see below and Section 5.4)
- Optimization of the current budget to minimize HIV incidence and mortality reduction (annual average of USD 24 million) averts an estimated 16,100 additional HIV infections and 10,200 additional deaths during the period 2014–30, compared with the current allocation
- If coordination and planning of programs got 25% less funding than now (corresponding with a decrease of 16.8% in funding for management, HR and research), and other indirect programs that have societal benefits beyond HIV prevention and care (OVC with social protection and environment, blood safety) were funded from a different source, the additional resources would be used to further increase the budget for ART (up to 53% of the budget) and spending on HTC would increase from 3.5% in the current allocation up to 8.8%. Spending for PMTCT would increase from 3.1% to 4.9% of the budget. Funding for FSW and MSM non-ART programs would further increase, to 3.9% and 1.1%, respectively. Spending for FSW and MSM, including ART, would increase by 83% and 100% (Figure 5.7), respectively. Spending for PWUD would be decreased even with the

higher budget, but as most of the PWUD in Senegal do not inject, most of the benefits of PWUD programs are outside of HIV. Hence, it may be important to keep the PWUD funding at the current level for social benefits of PWUD programs, but preferably not from the HIV budget

Figure 5.6 Current and optimal allocation of the current budget for long-term impact



Source: Authors

Table 5.2 Current Current and optimal allocation of the current budget for long-term impact

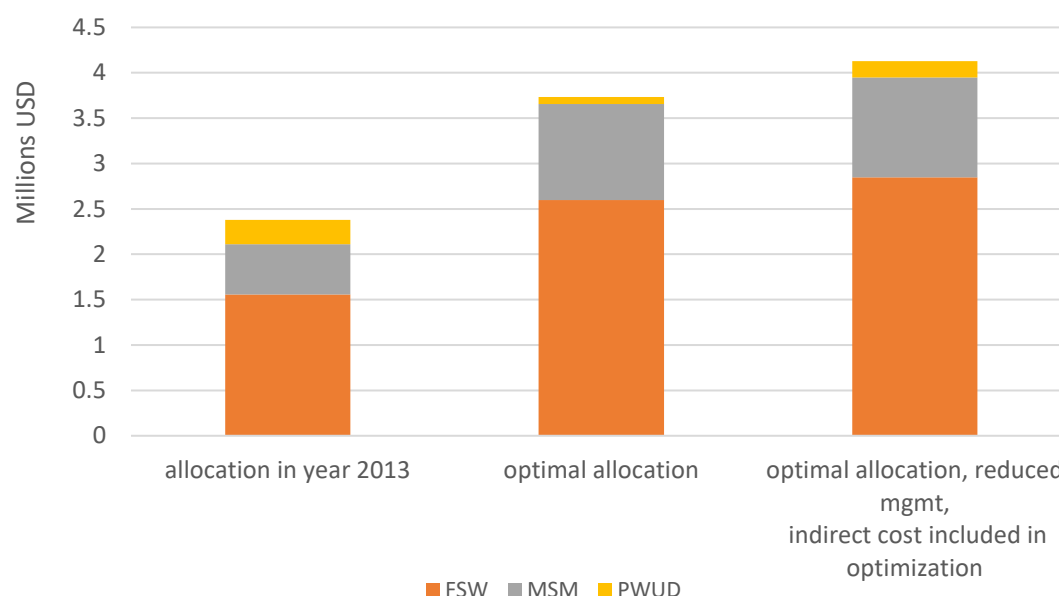
	Current allocation		Optimal allocation		Optimal allocation (reduced management costs)*	
	USD	%**	USD	%**	USD	%**
STI	237,530	1.0%	237,530	1.0%	—	0.0%
Blood Safety	890	0.0%	890	0.0%	—	0.0%
OVC	1,827,885	7.6%	1,827,885	7.6%	—	0.0%
MGMT	8,694,642	36.3%	8,694,642	36.3%	7,237,099	30.2%
PMTCT	744,230	3.1%	744,230	3.1%	1,010,441	4.2%
Condoms and SBCC	3,099,189	12.9%	11,610	0.0%	32,842	0.1%
non-ART FSW programs	627,290	2.6%	846,484	3.5%	1,038,355	4.3%
non-ART MSM programs	79,511	0.3%	227,947	1.0%	243,721	1.0%
non-ART PWUD programs	254,241	1.1%	53,872	0.2%	150,014	0.6%
HTC	844,735	3.5%	19,600	0.1%	1,791,803	7.5%
ART	7,558,313	31.5%	11,305,766	47.2%	12,468,181	52.0%
Total	23,968,456	100%	23,970,456	100%	23,972,457	100%

Source: Authors

Notes: * Management costs are reduced by 16.8% (representing a 25% reduction in the budget for planning and coordination). Blood safety and OVC are assumed to be funded from other sources, as these are not HIV specific programs, and they are needed in the country regardless of the HIV epidemic. The saved money is given free for optimization and reallocated to the direct programs;

**Proportion of total budget.

Figure 5.7 Total spending for key populations (including non-ART prevention programs and ART)



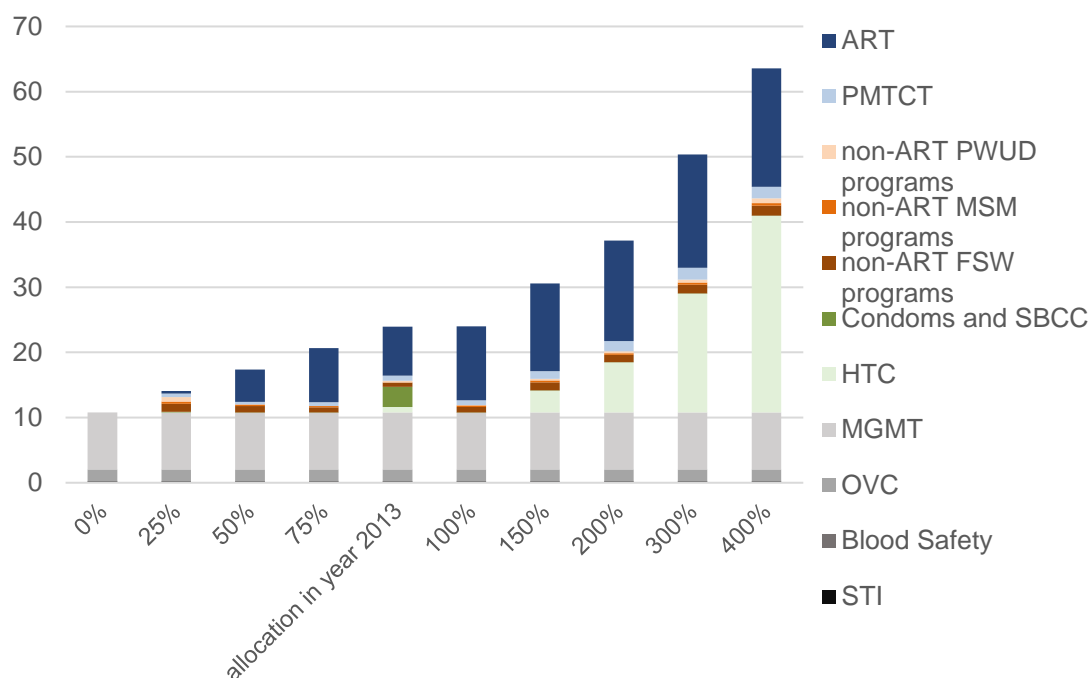
Source: Authors

These shifts in allocation emphasize the relatively high effectiveness of ART in population level reductions in HIV transmission and for individual clinical benefit. They also highlight the concentrated nature of Senegal's HIV epidemic, therefore recommending a shift away from prevention programs targeting the low-risk general population.

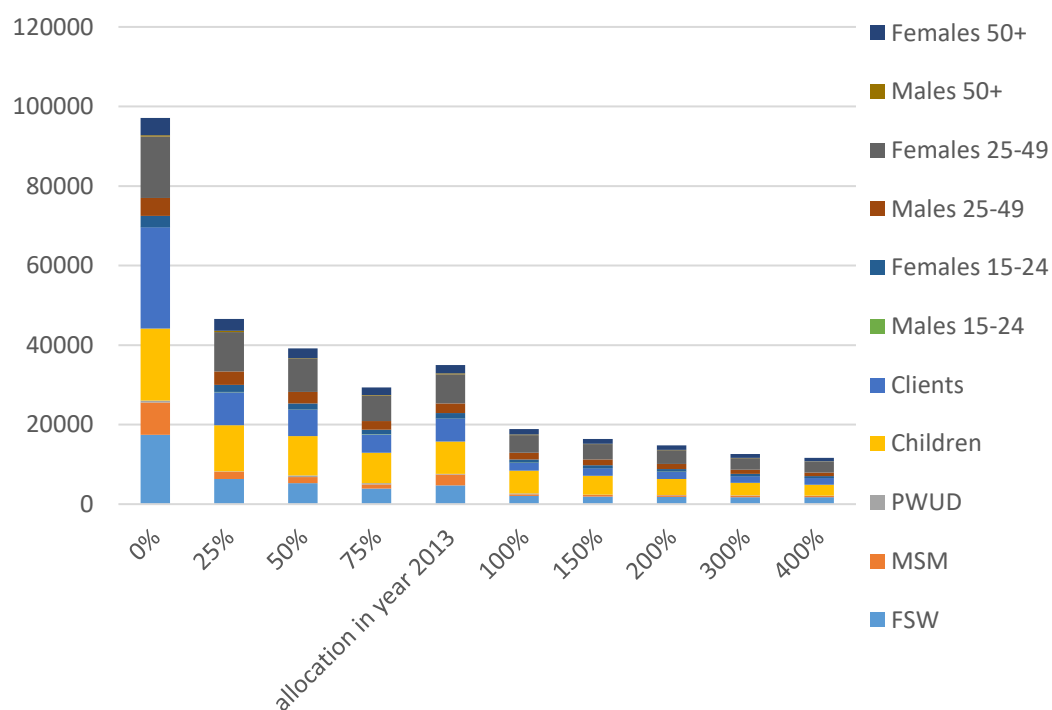
5.4 HIV INVESTMENT STAIRCASE

If HIV funds are either very limited or more abundant, allocations can be guided by an investment staircase that helps prioritize expenditures by HIV impact (Figure 5.8).

- If the total available funding decreases from the 2013 level, ART for the general and key populations should be given the highest priority, followed by spending on prevention programs targeting FSW and MSM—this explicit rationing is however not desirable since easily preventable HIV infections will occur within such a tight funding context
- With higher budgets, HTC is scaled up together with ART
- Even with larger budgets (up to 400% of the 2013 budget for direct programs), prevention programs for the low-risk population would still be given less than with the current allocation
- The impact of these investments on new HIV infections and HIV-related deaths is shown in Figure 5.9 and Figure 5.10, respectively

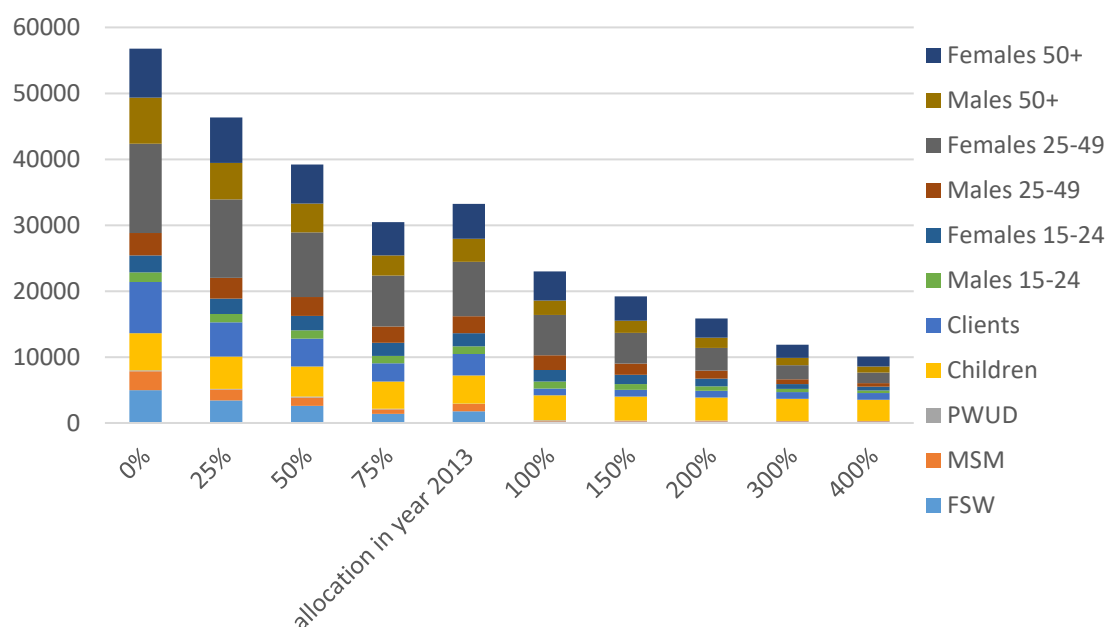
Figure 5.8 HIV investment staircase, Senegal

Source: Authors

Figure 5.9 Total number of new HIV infections that would result from different spending scenarios between 2014 and 2030

Source: Authors

Figure 5.10 Total number of hiv-related deaths that would result from different spending scenarios between 2014 and 2030



Source: Authors

5.5 EXPECTED FUTURE IMPACT OF POLICY AND PROGRAM IMPLEMENTATION SCENARIOS

The Optima model was used to analyse the influence of different scenarios on the projected future trajectory of the country's HIV epidemic. 2013 was used as the year of baseline expenditure.

5.5.1 INVESTMENTS IN SPECIFIC PROGRAMS

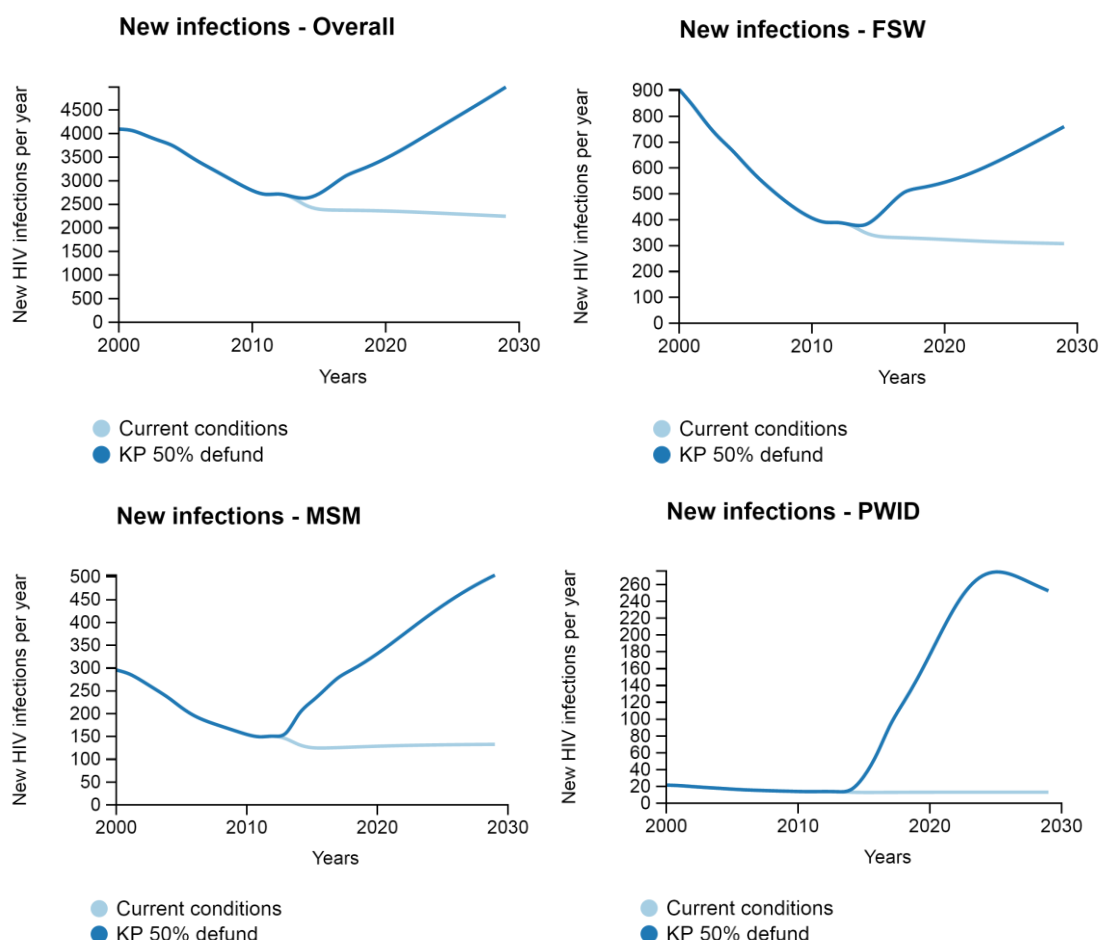
Scenario 1: What is the projected future trajectory of Senegal's HIV epidemic if non-ART HIV prevention programs for key populations are defunded?

Defunding non-ART HIV prevention programs targeting key populations would have a significant negative impact on the HIV epidemic as well as on long-term HIV-related costs.

In this analysis, we examined the influence of defunding non-ART HIV prevention programs for key populations (FSW, MSM and drug users (focusing on people who inject drugs, PWID)). We used 2013 as the year of baseline expenditure. For this scenario, we assumed that high-risk behavior among key populations would increase gradually, by 50% by 2017 (decrease in condom use between sex workers and clients, condom use between MSM and their casual partners, and the use of clean syringes and needles by PWID), while during the same period treatment-seeking behavior (uptake of HIV testing) would decrease by 50% compared with the level of the baseline year (2013). It is estimated that defunding non-ART HIV prevention programs for key populations would result in 22,700 more new HIV infections (10,600 in key populations

and 11,100 in the general population) and 4000 more HIV-related deaths (1,400 in key populations and 2,600 in the general population) by 2030 (Figure 5.11). Cumulative HIV-related costs between 2014 and 2030 would also increase by 17.9 million USD.

Figure 5.11 New HIV infections among the entire population and the key populations



Source: Authors

Notes: FSW, MSM and drug users under current conditions = light blue curves; Scenario with the defunding of key population non-ART prevention programs = dark blue curves.

5.5.2 ATTAINING PROGRAM-SPECIFIC NSP COVERAGE TARGETS

Scenario 2: What is the projected future trajectory of Senegal's HIV epidemic if, by 2017, coverage of HIV-positive pregnant women with ART for PMTCT increases to 90%?

Increasing the coverage of PMTCT from 51% up to 90% would avert new HIV infections and HIV-related deaths among children but the overall impact on the epidemic is small.

In this analysis, we examined a scenario in which the proportion of pregnant and breastfeeding women on ART (either already on ART or those initiating ART during pregnancy) increases from 51% gradually to 90% by 2017. We used the 2013 expenditure as baseline. About 380 HIV infections would be averted between 2014 and 2017 in children and 1300 HIV infections would be averted in children between 2014 and 2030. If scale up was quicker (achieving 90% coverage today), 800 and 2600

mother-to-child transmissions of HIV would be averted between 2014 and 2017 and between 2014 and 2030, respectively.

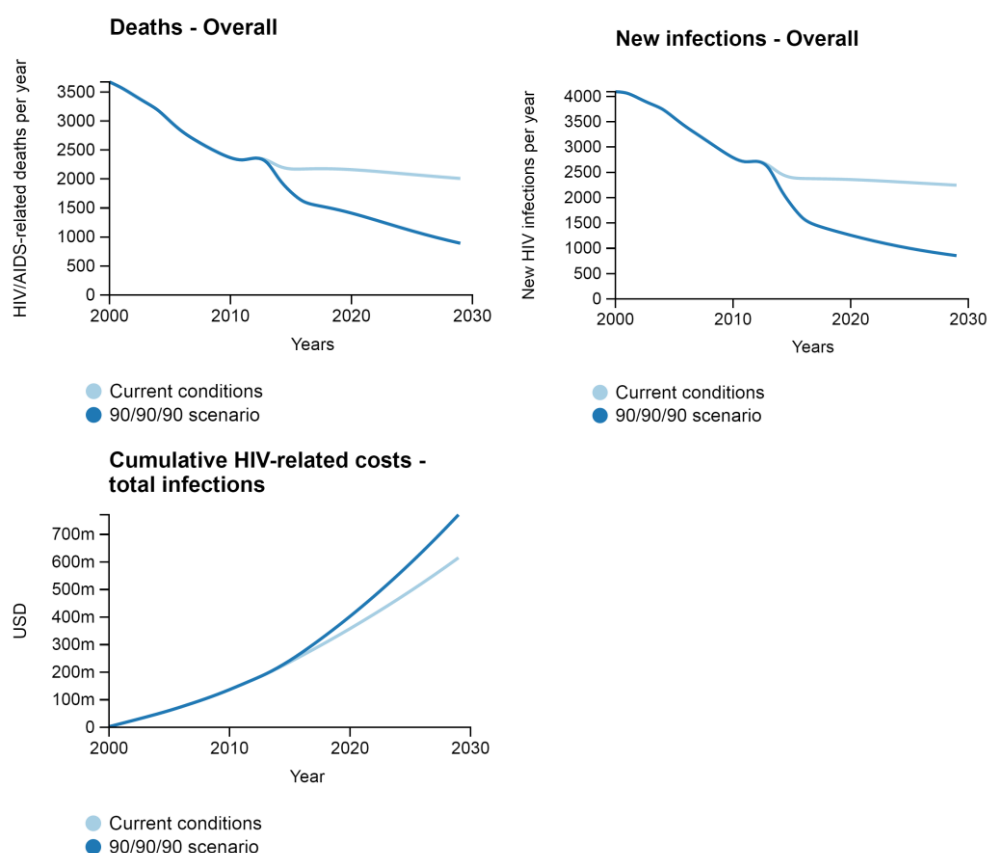
5.5.3 ATTAINING UNAIDS' 90/90/90 TARGETS

Scenario 3: What is the projected future trajectory of Senegal's HIV epidemic if, by 2020, 90% of all people living with HIV know their HIV status, 90% of all people with diagnosed HIV infection receive sustained ART, and 90% of all people receiving ART have viral suppression?

Reaching the global 90/90/90 targets would have a significant positive impact on the HIV epidemic as well as on long-term HIV-related costs.

In this analysis, we examined the impact of reaching the 90/90/90 goals on the HIV epidemic. We assumed the coverage of all other HIV-related programs, as well as the risk behavior among all populations, remains at the level of 2013. Reaching the 90/90/90 goals in Senegal would avert 17,300 new HIV infections and 12,600 HIV-related deaths by 2030 (Figure 5.12). Reaching the 90/90/90 goals would, however, be expensive—the cumulative HIV-related costs would increase by USD 156 million by 2030.

Figure 5.12 Projection of HIV-related deaths and new infections with current conditions and with reaching the 90/90/90 goals



Source: Authors

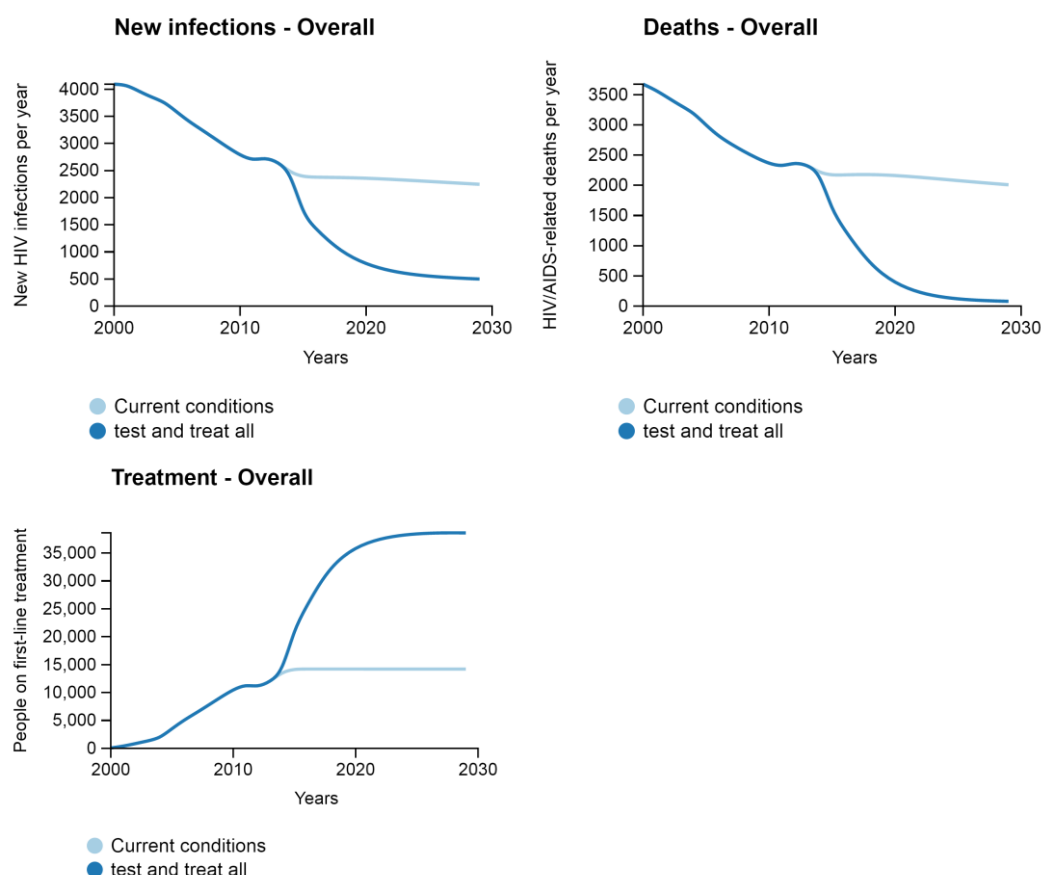
5.5.4 POLICY CHANGE REGARDING TREATMENT ELIGIBILITY

Scenario 4: What is the projected future trajectory of Senegal's HIV epidemic if the country implements a universal 'test and treat' strategy?

A 'test and treat' strategy would have a significant positive impact on the HIV epidemic.

In this analysis, we modeled the impact of introducing a 'test and treat' strategy on the HIV epidemic, i.e., increasing the scale-up of testing, and initiating ART immediately for all diagnosed patients regardless of the CD4 cell count. We assumed the coverage of all other HIV-related programs, as well as the risk behavior among all populations, remained at the 2013 level. We used 2013 as the year of baseline expenditure. If 'test and treat' was implemented between 2014 and 2017, 22,800 new HIV infections and 25,000 HIV-related deaths would be prevented between 2014 and 2030 (Figure 5.13). The cumulative costs related to HIV between 2014 and 2030 would, however, increase by 60%, from 615 million with current conditions to around 985 million US dollars.

Figure 5.13 Projected number of new HIV infections, HIV-related deaths and people on treatment for "test and treat" scenario



Source: Authors

Section 6

DISCUSSION

6.1 EPIDEMIC SPREAD AND POTENTIAL

Senegal has a concentrated HIV epidemic, with an overall HIV prevalence of 0.53% among adults aged 15–49 years. The prevalence among certain key populations, such as FSW (18.5%), MSM (17.8%), and drug users (5.2%), is substantially higher. Senegal was the first sub-Saharan African country to subsidize antiretroviral therapy against HIV. The early and timely response of the Senegalese government is probably one reason why the overall prevalence has remained at a low level. The prevalence reached its peak value of 0.9% in 2004 and has been decreasing since then. Our predictions show that this decreasing trend will continue in the next 15 years assuming continued financial investment in the national HIV response.

The current National Strategic Plan (2014–17) has set the target of reducing the number of new infections and HIV-related deaths by 50% by 2017. The country's current response to the HIV epidemic, including antiretroviral therapy and related HIV care, as well as prevention and testing programs targeting both the key and general population, can prevent about 14.8% of new HIV infections and 4.3% of HIV-related deaths over the NSP period. This means that with the current HIV budget and current allocation of financial resources across programs, the targets of the NSP cannot be achieved. Optimal allocation of the same resources, however, would prevent 1,400 (49.3%) of new infections and 700 (31%) of HIV-related deaths. The cost of reducing the number of HIV-related deaths by 50% within 4 years would be high: an additional USD 22 million every year would be required. Based on the analysis, it is recommended that the allocation of financial resources for HIV should be reconsidered, favoring the scale-up of ART for both the general and the key populations and the scale-up of non-ART prevention programs for FSW and MSM programs, while reducing financial resources focused on non-ART prevention among the low-risk general population. With a larger budget (from savings from indirect programs) HTC and PMTCT would be prioritized. This is further supported by the two scenarios analyzed that relate to the scale up of treatment (a test and treat strategy and achieving UNAIDS' 90/90/90 treatment targets). A test and treat strategy was estimated to avert 22,800 new infections and 25,000 HIV-related deaths between 2014 and 2030. Achieving the global 90/90/90 targets in Senegal by 2020 was estimated to avert 17,300 new infections and 12,600 HIV-related deaths between 2014 and 2030.

6.2 FUNDING FOR HIV INTERVENTIONS

Like most resource-constrained countries, Senegal relies heavily on international support for financing the HIV response. In 2013, 42% of the total HIV funding came from the Global Fund. About one-fourth of the HIV response was financed from domestic sources, primarily public funding but also direct household spending. During the past few years, international financing has decreased and this decrease is expected to continue. No international funding has yet been secured beyond 2017.

A situation whereby international financing for the HIV response continues to decrease leads to several considerations. An HIV transition plan should be developed for the sustainability of Senegal's HIV response that identifies the nature and temporal dimension of the transition that will be needed from a governance/institution, service delivery and financial perspective. First, the uncertainty in long-term international funding means that the country should attempt to mobilize more domestic resources. In addition to increased public funding, the involvement of private companies and enterprises in the national HIV response should be promoted and supported.

Second, the country must be prepared for declines in international funding and understand the possible consequences. Currently, all the key population programs are funded solely from international sources. We demonstrated that defunding of the FSW, MSM and PWUD HIV prevention programs targeting PWID—that may happen if there is a substantial decrease in international donor funding—would cause almost 22,700 new infections and almost 4,000 HIV-related deaths by 2030. The majority of these new infections and deaths would occur in the general population. The general population is affected by the epidemic among key populations through bridge populations: for example, clients of sex workers transmit HIV infection from FSW to young low-risk females. While incidence is higher among the key populations, the majority of these new infections still occur among the general low-risk population because of the relatively small population size of the key population groups. This shows that programs targeting key populations are also important in protecting the general low-risk population, and they have likely played a role in preventing a generalized epidemic in Senegal. Finally, the likely decrease in total funding calls for more efficient use of the available resources. It is essential that Senegal maximizes the health benefits from the resources it has, both international and domestic. This can be done through a more optimal allocation of resources across programs and populations.

The analysis we conducted answers the questions *"How the existing funding could be allocated more efficiently?"* and *"Where the additional funding needed to achieve the HIV program goals should be allocated?"*. The investment staircase indicates which programs should have priority with different available funding levels. These results indicate which shifts of funding could be more efficient compared with the allocations planned for the NSP and the Global Fund Concept Note.

6.3 OPTIMAL HIV RESOURCE ALLOCATION

In our optimization analysis, we found that resources should be shifted from non-ART prevention interventions targeting the general population towards treatment for everyone, and non-ART prevention programs focusing on FSW and MSM. The reasons behind the shift towards treatment, in particular antiretroviral therapy, are easy to understand. As demonstrated by Cohen et al⁴⁶, antiretroviral therapy not only helps the treated patients, but also effectively prevents onward transmission. Globally, the role of ART in HIV responses is underscored in strategies and targets such as the “90-90-90” launched by UNAIDS, which focuses on diagnosing people living with HIV, initiating them onto therapy, and maintaining viral suppression among those on treatment. This demonstrates that treatment is now also seen as a major method of prevention. In a concentrated epidemic like Senegal, key populations (in particular MSM and FSW) are the key epidemic drivers. Focusing on the prevention among those populations allows to reduce new infections also in the general population, by reducing the number of new infections in bridge populations.

In our model, ART was not divided according to population groups, since we expect that all patients diagnosed with HIV should have equal access to therapy according to the guidelines in place, regardless of their individual characteristics or risk behavior. According to our results, funding for general population testing should be decreased, since more resources are needed for antiretroviral therapy (given the large treatment gap). However, as soon as more budget is available, the HTC budget should be scaled up together with ART. Condom and SBCC programs for the general population were clearly defunded in the optimized allocation. Programs promoting condoms and less risky behavior among the general population only prevent HIV acquisition or transmission if these programs have a high impact; being targeted by a promotion campaign does not directly imply any behavioral changes and the impact of such programs for the general population are questionable. HTC on the other hand is also needed to promote ART, by identifying HIV-infected people as early as possible. Of the key population programs, funding for non-ART prevention programs targeting FSW was increased by 35%, budgets for MSM non-ART prevention programs were increased by 190%, and drug user programs were almost completely defunded. Targeting FSW and MSM can prevent new infections among the bridge populations (FSW clients and mobile populations, for example, and MSM’s female partners) efficiently, and stop the spread of the epidemic into the general population. The strong defunding of drug user programs may be related to the mode of drug consumption: only about 14% of the population classified as drug users in Senegal reported consuming drugs intravenously during the last month. This means that the epidemic among PWUD in Senegal is probably at least partly due to sexual transmission and risky behavior associated with drug use. Nevertheless, both HIV prevalence and incidence are higher among the subgroup of injecting drug users. Programs targeting all PWUD homogenously may therefore be much less effective than,

⁴⁶ Cohen et al. 2011. Prevention of HIV-1 Infection with Early Antiretroviral Therapy. *N Engl J Med* 2011; 365:493-505

for example, needle exchange programs in countries where drugs are mainly consumed intravenously. Furthermore, as our defunding scenario analysis showed, a situation whereby high-risk injecting behavior increases would result in a considerable number of new infections and deaths among PWUD and the general population.

6.4 STRENGTHS AND LIMITATIONS

Mathematical modeling is a powerful tool to make future predictions of the development of epidemics. Models can be based on existing evidence and parameterized with routine observational data. This analysis was performed using Optima, a widely recognized model of HIV disease progression and transmission. Optima has been used for similar allocative efficiency studies for a number of countries worldwide. These studies have helped to advise countries how their financial resources should be used to prevent as many new infections and deaths as possible, and the results have also promoted changes in the HIV funding allocations during the recent years.

However, we must acknowledge some limitations. There is great uncertainty around some of the input parameters, which also leads to uncertainty in the outcomes. The key inputs of Optima include the size and HIV prevalence of each population group, and the costs, coverage and impact of each program. In particular, the sizes of the key populations are often challenging to estimate. The data are often based on small surveys, which are not representative in terms of the age and geographic distribution of the whole country, for example. The data on key populations that were used in this study were mainly based on the capital city Dakar, and extrapolation of these results to the entire country was needed. Whereas accurate cost data were available for most programs, the coverage and impact of programs such as condom promotion/SBCC and the key population prevention programs were difficult to estimate.

Section 7

CONCLUSIONS

Senegal has been able to respond effectively to the HIV epidemic, and the national response for preventing and treating HIV/ AIDS continues according to the country's current National Strategic Plan (2014–17). However, this response strongly relies on international donor funding, which is currently decreasing and its availability in the long-term is uncertain. There is an urgent need to mobilize additional domestic resources, and reallocate the currently available funding (as well as any future financial resources mobilized) in a manner that maximizes the health benefits. Senegal's epidemic is driven by small high-risk populations, and our findings have shown that interventions targeting these populations are essential for controlling the epidemic, and preventing new infections and deaths among the general population also. With the funding currently available, resources should be shifted from non-ART prevention interventions targeting the general low-risk population towards treatment for all and non-ART prevention programs targeting the key drivers of the epidemic (FSW and MSM). Achieving the targets of the National Strategic Plan would require an additional USD 22 million yearly during the NSP period.

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Section 8

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ANNEX 1

TECHNICAL DATA IN OPTIMA HIV MODEL

A1.1 DATA COLLATION AND SYNTHESIS

Performing our evaluations of HIV prevention and treatment programs required a large amount of data describing the HIV epidemiology, population demographics, acquisition related behavior, clinical characteristics, and HIV program and health costs.

A1.1.1 DATA COLLATION

In order to evaluate programs, their funding, coverage and outcomes we collated data from all available publications, documents, reports, and data files. The data included:

- a. Estimated population sizes for different age groups of the general population and the key populations or most at-risk populations (MARPs).
- b. The epidemiological characteristics of the HIV epidemic. Specifically, we obtained data on HIV prevalence, annual HIV diagnoses, number of people currently on first- and second-line antiretroviral therapy (ART), and number of reported or estimated mother-to-child transmissions.
- c. Descriptions of risk behavior, HIV transmission patterns, and health-care seeking behavior. We used this data to understand modes of HIV transmission between populations and the risk of HIV acquisition. Specific data collected includes characteristics of sexual behavior (number of sexual acts with regular, casual and commercial partners and level of condom usage in sexual acts), and rates at which people in specific populations test for HIV.
- d. HIV program funding, spending data from National AIDS Spending Assessments and health utilities for PLHIV at all stages of disease progression.

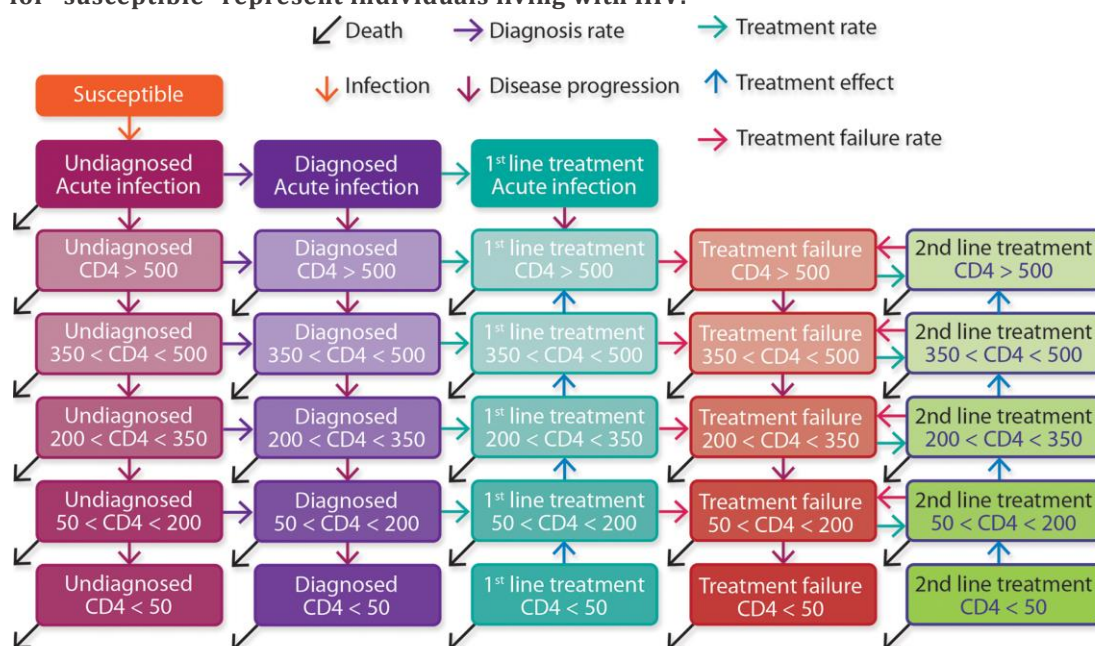
A1.1.2 THE OPTIMA HIV MODEL

We use the Optima HIV model to calculate the change in HIV incidence and in the number of HIV/AIDS deaths due to changes in funding. Optima HIV is sufficiently flexible to track epidemiological and behavioral parameters over time to produce long-term forecasts, and to allow us to conduct allocative efficiency analyzes. Optima HIV uses best-practice HIV epidemic modeling techniques and incorporates realistic biological transmission processes, detailed infection progression, sexual mixing patterns and drug injection behaviors. Optima HIV describes the impact of HIV programs indirectly through their influence on behavioral and clinical parameters.

A1.1.3 Model of HIV Transmission and Progression

Optima HIV incorporates a model of HIV transmission and progression. The model uses a coupled system of ordinary differential equations to track the transmission of HIV and the movement of infected people between 21 health states (Figure A1.1). The model distinguishes people who are undiagnosed, diagnosed, and on effective antiretroviral therapy (ART). Diagnosis of HIV-infected individuals occurs based on a HIV testing rate dependent on CD4 count and population type. Similarly, diagnosed individuals begin treatment at a rate dependent on CD4 count. The model tracks those on successful first- or second-line treatment (who have an increasing CD4 count) and those with treatment failure.

Figure A1.1 Schematic diagram of HIV infection progression. Each compartment represents a single population group with the specified health state while each arrow represents the movement of individuals between health states. All compartments except for “susceptible” represent individuals living with HIV.



Source: Authors.

HIV infections occur through the interaction between different populations via regular, casual, or commercial sexual partnerships. The force-of-infection for a population determines the rate at which uninfected individuals within the population become infected. This depends on the number of risk events individuals are exposed to in a given period and the infection probability of each event. Sexual transmission risk depends on:

- The number of people in each HIV-infected stage (that is, the prevalence of HIV infection in partner populations)
- The average number of casual, regular and commercial homosexual and heterosexual partnerships per person
- The average frequency of sexual acts per partnership

- The proportion of these acts in which condoms are used
- The efficacy of condoms
- The extent of male circumcision
- The prevalence of ulcerative STIs (which increase transmission probability)
- The stage of infection (chronic, AIDS-related illness/late stage, or on treatment) for the HIV-positive partner in a sero-discordant couple also influences transmission risk— due to different levels of infectiousness in each infection stage

Mathematically, we calculate the force-of-infection using:

$$\lambda = 1 - (1 - \beta)^n$$

where λ is the force-of-infection, β is the transmission probability of each event, and n is the effective number of at-risk events per year (thus n gives the average number of interaction events with infected people where HIV transmission may occur). The value of the transmission probability is inversely related to the CD4 count (<http://www.optimamodel.com/docs/optima-parameter-priors.pdf>). It differs for different modes of transmission (heterosexual or homosexual intercourse, intravenous drug injection) and may be modified by behavioral interventions (for example, condom use or circumcision). The number of events n not only incorporates the total number of events, but also other factors that may limit the possibility of transmission, such as condom use or circumcision. There is one force-of-infection term for each type of interaction and the force-of-infection for a given population will be the sum of overall interaction types. Optima HIV calculates the number of children infected through mother-to-child transmission using the birthrate and prevalence of HIV in female population groups. Children who are breastfed have a higher risk of acquiring HIV than those who are not breastfed in the model. Prevention of mother-to-children programs reduce the overall probability of children acquiring HIV through a multiplicative factor equal to one minus the product of the efficacy of PMTCT and coverage of PMTCT. In addition to the force-of-infection rate, which determines how individuals move from uninfected to infected states, individuals may move between health states via seven other pathways:

- Individuals may die, either due to the background death rate (which affects all populations), due to injecting behavior, or due to HIV/AIDS (which depends on the CD4 cell count)
- In the absence of intervention, individuals progress from higher to lower CD4 cell counts
- Individuals can move from undiagnosed to diagnosed states based on their HIV testing rate, which is a function of the CD4 count (for example, people with AIDS symptoms have a higher testing rate) and population type (for example, IDUs usually get tested more frequently than low-risk males)

- Diagnosed individuals may move on to treatment, at a rate dependent on CD4 count
- Individuals on treatment (first- or second-line) may experience treatment failure
- Individuals on failing treatment may switch to second-line treatment
- While on successful first- or second-line treatment, individuals may progress from lower to higher CD4 count

In total, the model for Senegal accommodates 247 compartments (13 populations each with 19 health states), and the change in the number of people in each compartment is determined by the sum over the relevant rates described above multiplied by the compartments on which they act. For example, the number of individuals in the compartment corresponding to undiagnosed female sex workers with a CD4 count between 200 and 350 cells/ μ L changes according to the following equation:

$$\frac{dU_{FSW200-350}}{dt} = U_{FSW350-500}\tau_{350-500} - U_{FSW200-350}(\mu_{200-350} + \tau_{200-350} + \eta_{FSW_{350-500}})$$

Where $U_{FSW200-350}$ is the current population size of people with undiagnosed HIV and with a CD4 count between 350 and 500 cells/ μ L, $U_{FSW200-350}$ is the population size of the compartment with lower CD4 count (200–350 cells/ μ L), τ is the disease progression rate for the given CD4 count, μ is the death rate, and η is the HIV testing rate. (Note: this example does not consider movement between populations, such as female sex workers returning to the low-risk female population and vice versa.) Each compartment (boxes in Figure A1.1) corresponds to a single differential equation in the model, and each rate (arrows in Figure A1.1) corresponds to a single term in that equation. Most of the parameters in the model are related to calculating the force-of-infection; a list of model parameters is provided in Table A1.1. We interpret empirical estimates for model parameter values in Bayesian terms as prior distributions.

Table A1.1 Model parameters

	Biological parameters	Behavioral parameters	Epidemiological parameters
Population parameters	Background death rate		Population sizes (TP)
HIV-related parameters	Sexual HIV transmissibility* (H) STI-related transmissibility increase* Condom efficacy* Circumcision efficacy* HIV health state progression rates (H) HIV-related death rates (H)	Number of sexual partners* (TPS) Number of acts per partner* (S) Condom usage probability* (TP) Circumcision probability* (T)	HIV prevalence (TP) STI prevalence (TP)
MTCT parameters	Mother-to-child transmission probability	Birth rate PMTCT access rate (T)	

Table A1.1 Model parameters (continued)

	Biological parameters	Behavioral parameters	Epidemiological parameters
Treatment parameters	ART efficacy* ART failure rates	HIV testing rates (TPH)	Number of people on ART (T)

Source: Authors

Note: T = parameter value changes over time; P = parameter value depends on population group; H = parameter depends on health state; S = parameter depends on sexual partnership type; * = parameter is used to calculate the force-of-infection.

A1.1.4 CALIBRATION TO THE HIV EPIDEMIC DATA

We calibrated Optima HIV to Senegal's HIV epidemic to match available population group HIV prevalence data, overall annual diagnoses, and the uptake of ART. While primarily calibrated to match epidemiological data, Optima HIV also optimizes input parameters to match available demographic, behavioral, biological and clinical data. Given the challenges inherent in quantifying all known constraints on an epidemic, we calibrated the model manually, with oversight by and collaboration with in-country stakeholders where possible.

A1.1.5 RECONCILIATION WITH COST-OUTCOME RELATIONSHIPS

The parameter values for the best-fit simulation in 2014 need to match the outcome values corresponding to the estimated 2014 spending levels in the cost-outcome relationships (described in detail in Annex 2). Otherwise, there will be a mismatch in parameter values for future projections and a sharp change in epidemiological trends even if there is no change in spending. Depending on the parameters affected or the available country data, we either adjust the calibration to match the data used in the logistic cost-outcome curves or adjust the cost-outcome curves to match the calibration.

A1.2 Optimal allocation

To investigate the potential impact of future HIV prevention programs we ran model projections into the future from 2014 under different investment or programmatic scenarios.

A1.2.1 OPTIMIZATION OF PROGRAM ALLOCATION

The primary aim for our analysis is to determine the allocation of resources or spending required that best meet the specific objectives described in Section 1.2 of the report. For each of these objectives we used Optima HIV with the best-fitting simulation and an adaptive stochastic linear gradient-descent optimization method to determine the allocation of funding best achieving these objectives for a specific budget. In this method, Optima HIV starts with a fixed budget with program funding allocated randomly. At each step of the optimization process Optima HIV determines the expected behavioral and clinical parameters associated with each program's funding level using the logistic cost-outcome relationships.

ANNEX 2

COST-OUTCOME CURVES

A central component of our analyses is the relationships between the cost of HIV prevention programs and the resulting outcomes. Such relationships are required in our analyses, to understand how incremental changes in spending ultimately affect HIV epidemics and determine the optimal funding allocation. Our analysis requires country specific relationships for each risk-population and prevention program. A large amount of behavioral and spending data is required, to inform such relationships. We used an ecological “top-down” approach to relate program cost and outcomes. For each population at risk, we derived a set of relationships directly linking estimated funding to behavioral data for the population’s primary risk-behavior. We describe our approach in detail below. To produce these relationships, we assume indirect costs have no direct impact on HIV transmission parameters; but changes to HIV programs may affect these costs to supply additional condoms, clean syringes, and methadone, for example. A limitation of our approach is the assumption that all changes in behavior are assumed to be due to changes in program funding.

A2.1 METHODOLOGICAL DETAILS

We use a logistic or sigmoid function to model cost-outcome relationships. This type of function can incorporate initial startup costs, which may have no direct effect on a behavioral outcome, and allow changes in behavior to saturate at high spending levels. Using our data synthesis, we identified years where both spending data and outcome data were available for each model population. We then used this data to fit a four parameter logistic function of the form, where x is the estimated amount of funding for the population, A is the lower asymptote value, B is the upper asymptote value, C is the point of maximum change, and D is the growth rate. Our fits were further constrained using an assumed range for the maximum/saturation value of the outcome. We estimated this saturation range subjectively, based on data from high income countries where funding is effectively unlimited. We fitted the logistic function to the available data and saturation range using Matlab® 2013a with a trust region reflective algorithm.

ANNEX 3

MODEL CALIBRATION RESULTS

The calibrations to HIV prevalence data points and number of people on ART are shown in Figure A3.1

The black dots represent available data for HIV prevalence. The solid curve is the best fitted estimation of HIV prevalence in each sub-population. For the panel Treatment-Overall, the black dots represent available data for the number of people on ART and the solid curve is the number of patients on ART according to the simulation using the best fit.

Figure A3.1 Calibration of Optima model to the HIV epidemic in Senegal (HIV prevalence and ART data)

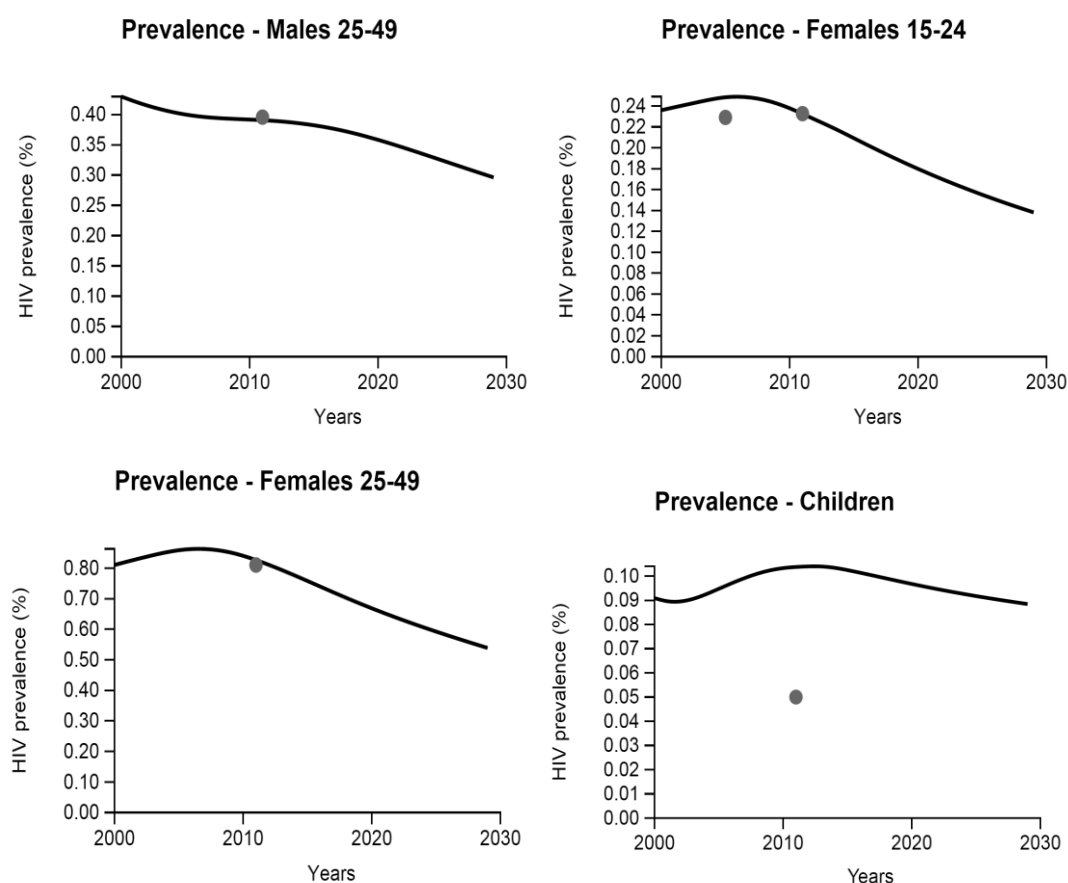


Figure A3.1 Calibration of Optima model to the HIV epidemic in Senegal (HIV prevalence and ART data) (continued)

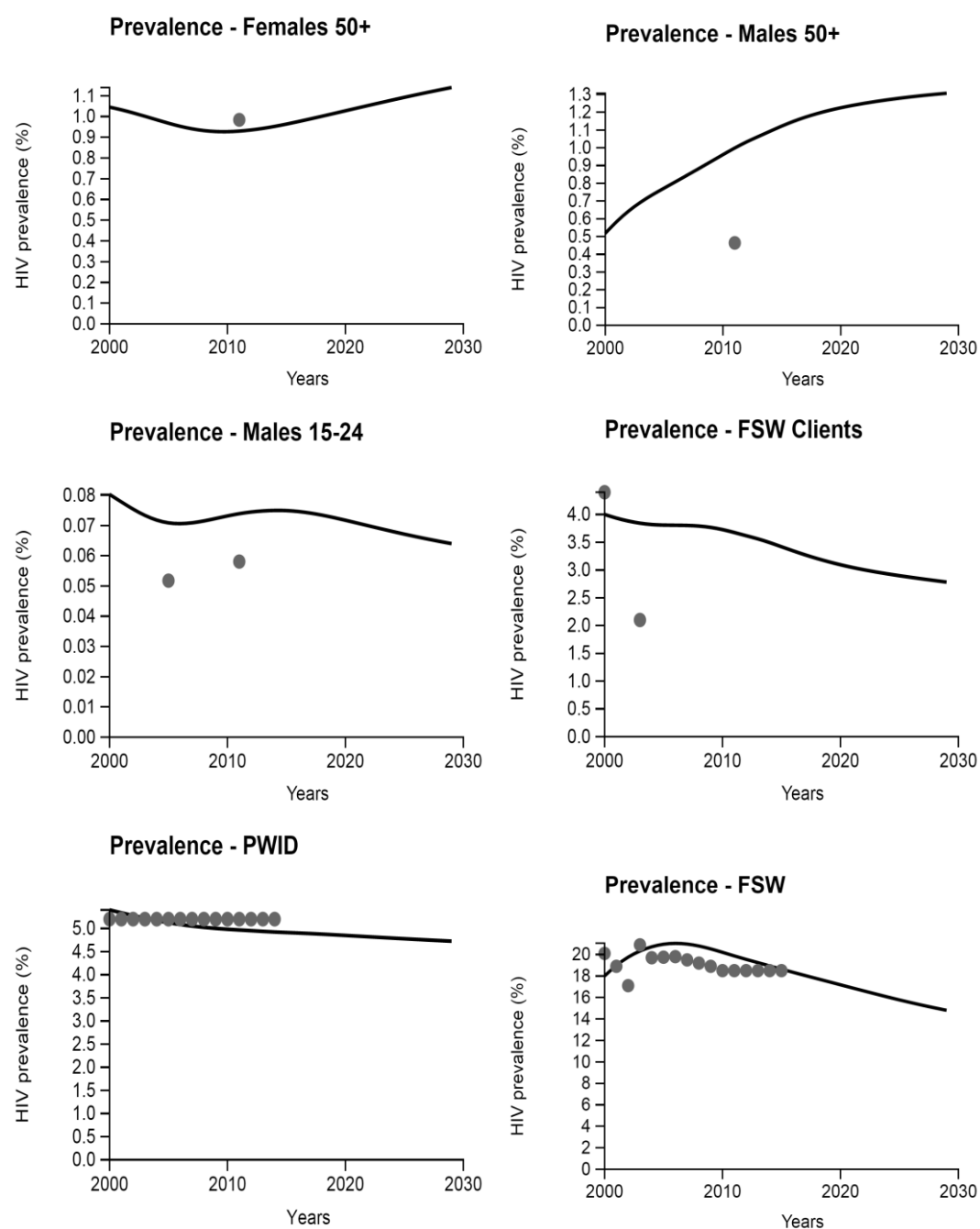
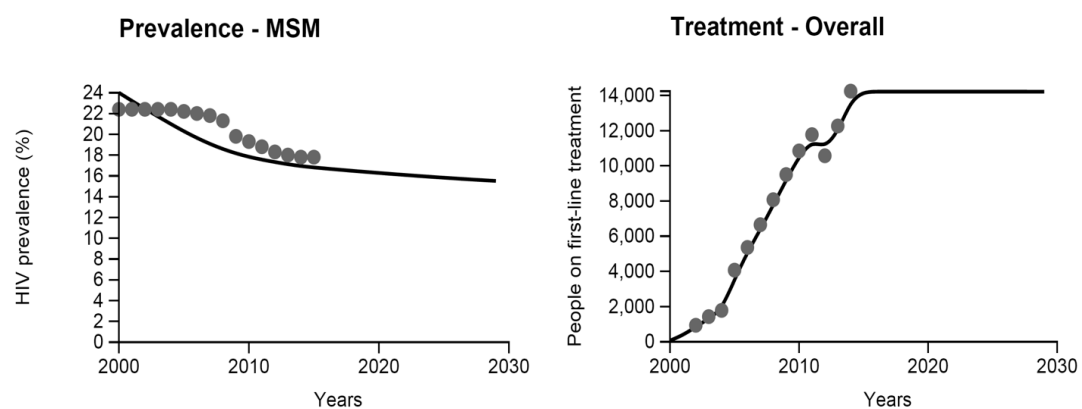


Figure A3.1 Calibration of Optima model to the HIV epidemic in Senegal (HIV prevalence and ART data) (continued)



Source: Optima HIV application, 2016.